

2006 ENGINE**Engine Mechanical - 4.6L (3 Of 5) - Lucerne****ENGINE BLOCK CLEANING AND INSPECTION - LOWER****CLEANING PROCEDURE**

1. Remove any old thread sealant and gasket material or sealant.
2. Clean all the following areas with solvent:
 - Sealing surfaces
 - Oil passages
 - Bearing journals
3. Clean all threaded and through holes with solvent.
4. Prior to the application of RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the engine block seal groove clean the groove and mating surfaces of the upper engine block and the mating surface of the lower crankcase with cleaner solvent GM P/N 12378392 or 12346139 (Canadian P/N 88901247).

CAUTION: Refer to SAFETY GLASSES CAUTION .

5. Dry the lower engine block with compressed air.

VISUAL INSPECTION

1. Inspect the crankshaft bearing journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the crankshaft rear oil seal bore for damage. The crankshaft rear oil seal bore is not repairable, if the crankshaft rear oil seal bore is damaged the cylinder block assembly must be replaced.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or excessive debris.
5. Inspect all bolts for damage, if damaged replace with new bolts only.
6. Inspect the crankshaft oil scraper for cracks or damage, replace if cracked or damaged.
7. Inspect the lower engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to **Thread Repair Specifications** and **Thread Repair**.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the following components in solvent:

- Crankshaft bearings
- Connecting rod bearings
- Crankshaft journals
- Crankpin journals
- Crankshaft oil passages
- Crankshaft threaded holes

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the following components with compressed air:

- Crankshaft bearings
- Connecting rod bearings
- Crankshaft journals
- Crankpin journals
- Crankshaft oil passages
- Crankshaft threaded holes

VISUAL INSPECTION

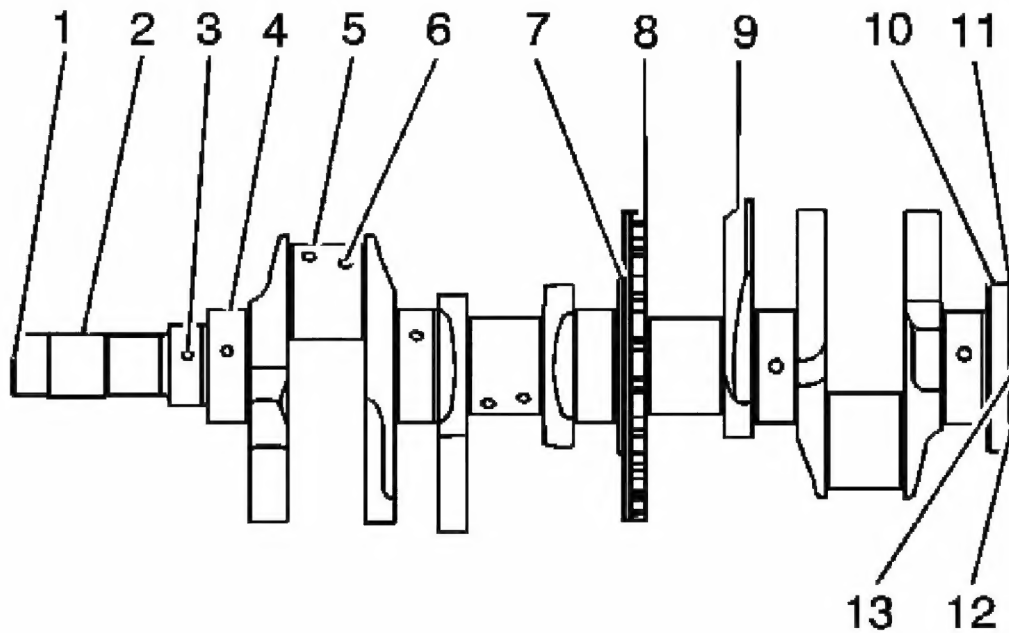


Fig. 1: Identifying Crankshaft and Bearings Components
Courtesy of GENERAL MOTORS CORP.

1. Perform the following visual inspections:
 - Inspect the crankshaft balancer bolt hole (1) for thread damage
 - Inspect the crankshaft balancer mounting area (2) for damage
 - Inspect the crankshaft sprocket pin hole (3) for damage
 - Inspect the crankshaft main journals (4) for damage
 - Inspect the crankshaft connecting rod journals (5) for damage
 - Inspect the crankshaft oil passages (6) for obstructions
 - Inspect the crankshaft main bearing thrust wall surfaces (7) for damage
 - Inspect the crankshaft reluctor ring teeth (8) for damage
 - Inspect the crankshaft counterweights (9) for damage
 - Inspect the crankshaft rear main oil seal surface (10) for damage
 - Inspect the crankshaft engine flywheel mounting surface (11) for damage
 - Inspect the crankshaft engine flywheel bolt holes (12) for thread damage
 - Inspect the crankshaft pilot hole (13) for damage
2. Repair or replace the crankshaft as necessary.

CRANKSHAFT BEARING INSPECTION

IMPORTANT: All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.

The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.

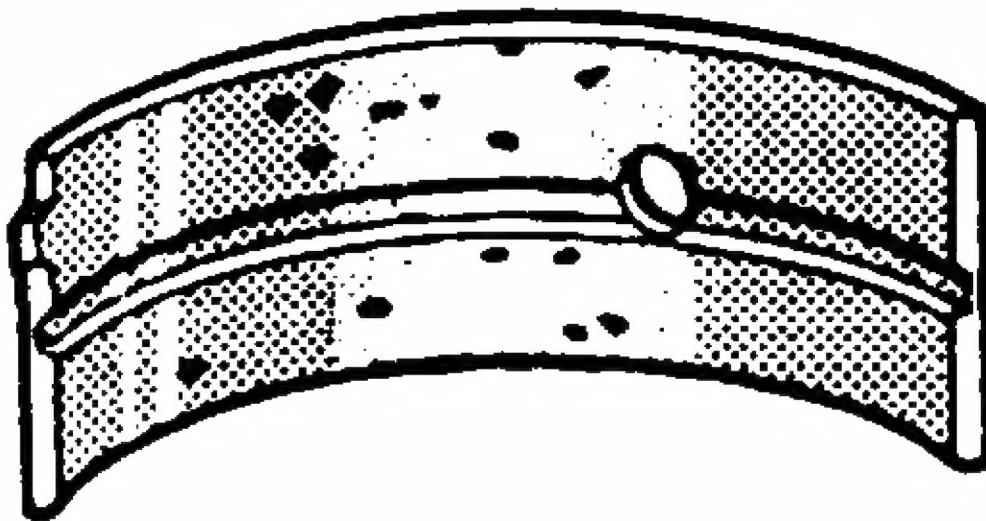


Fig. 2: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

1. Inspect for fatigue indicated by craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

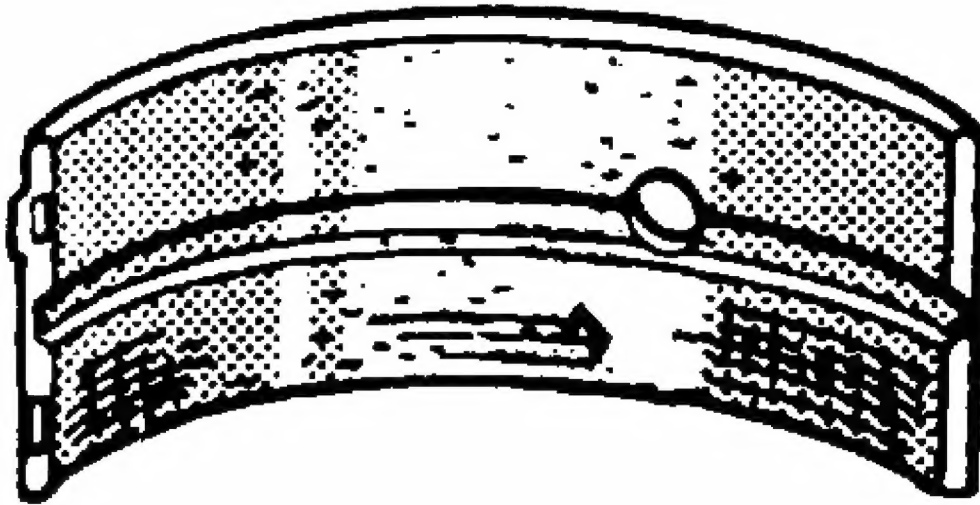


Fig. 3: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

2. Inspect for excessive scoring or discoloration on both front and back of the bearing halves.
3. Inspect the main bearings for dirt imbedded into the bearing material.

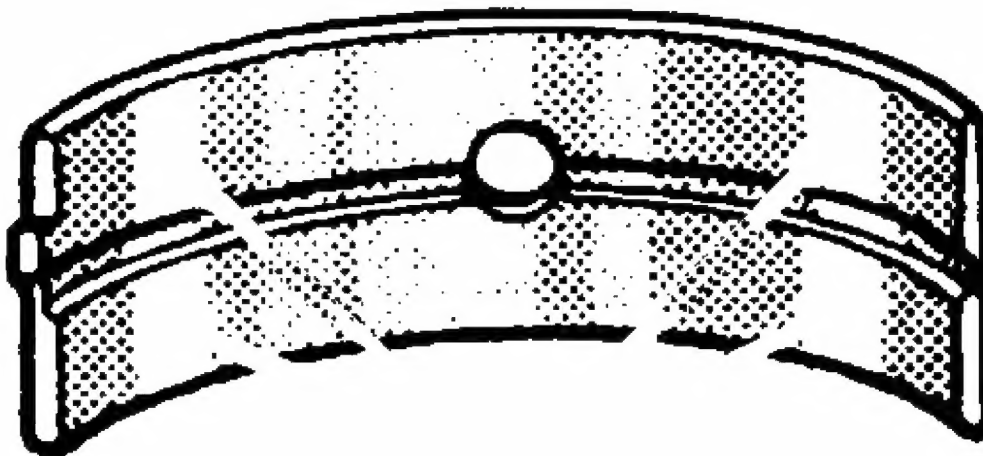


Fig. 4: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

4. Inspect for improper seating indicated by bright, polished sections.

CRANKSHAFT MEASUREMENT

Tools Required

J 7872 Magnetic Base Dial Indicator

Measurement Procedure

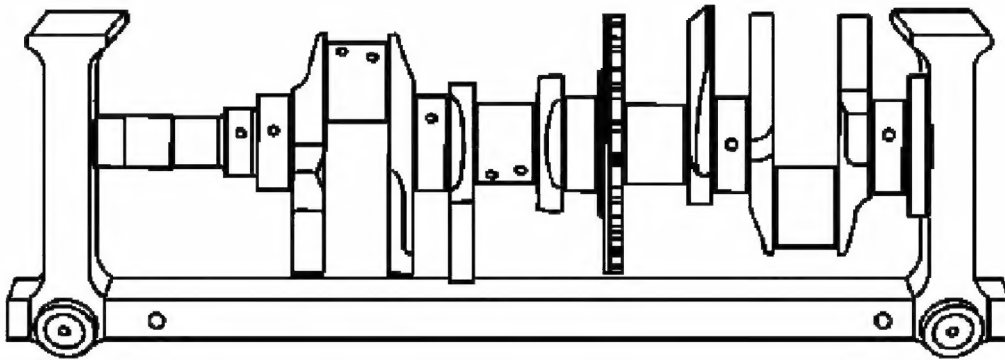


Fig. 5: Supporting Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Using a suitable fixture, support the crankshaft.

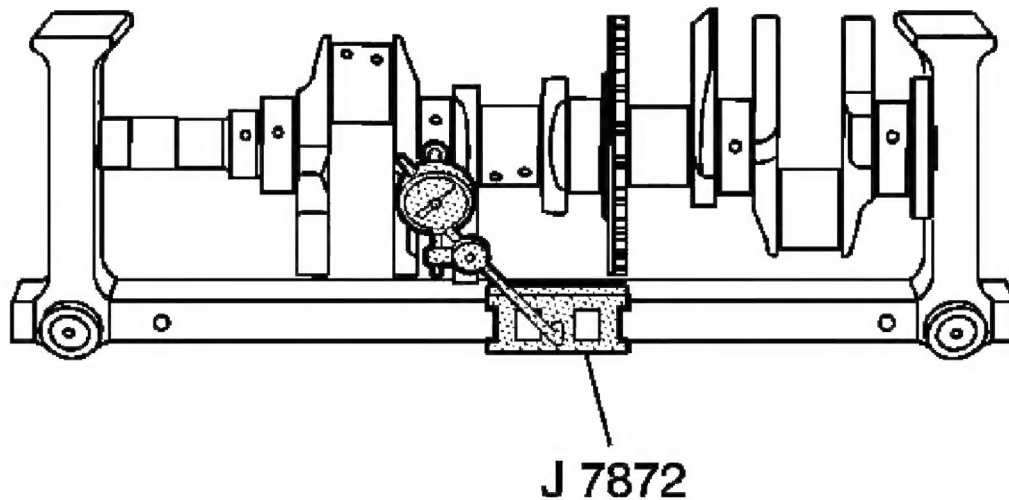


Fig. 6: View Of J 7872 Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 7872** .
3. Measure the crankshaft runout using **J 7872** . Refer to **Engine Mechanical Specifications** .

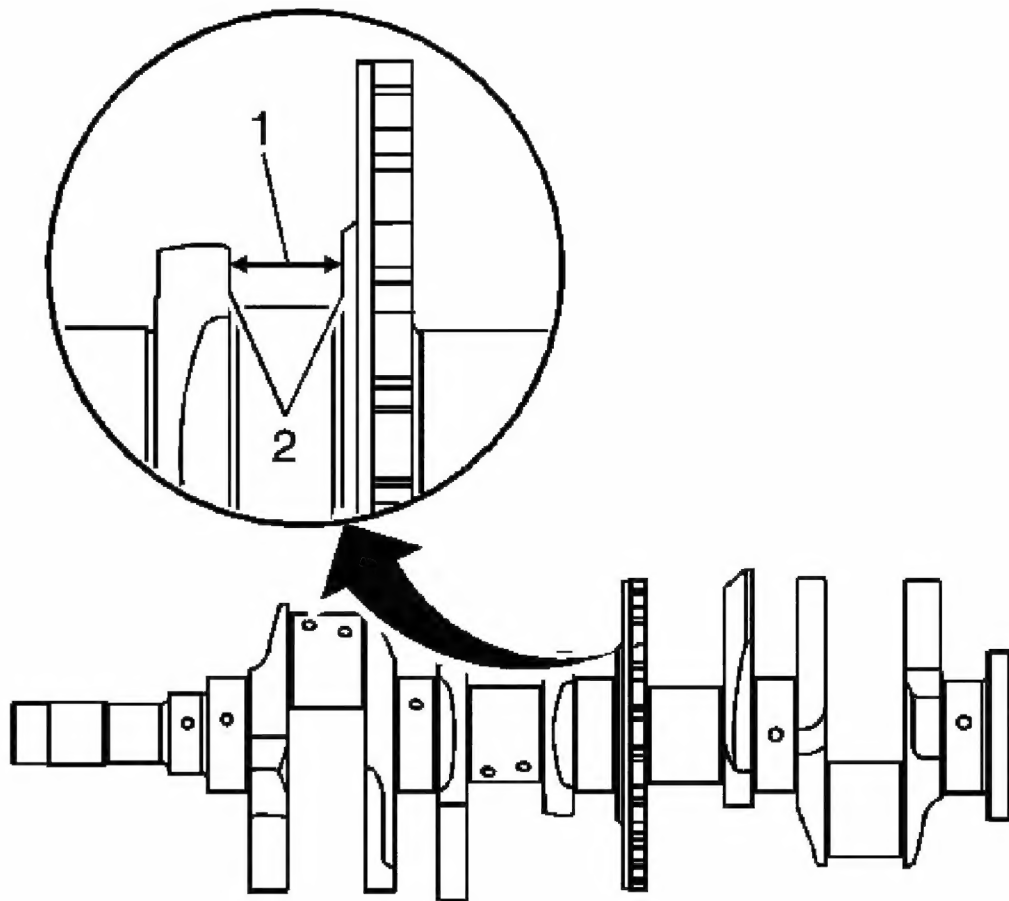


Fig. 7: Expanded View of Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS CORP.

4. Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications** .
5. Measure the crankshaft thrust wall surface (2) for runout using **J 7872** . Refer to **Engine Mechanical Specifications** .
6. If the crankshaft thrust walls are damaged or worn beyond specifications, replace the crankshaft. No machining of the crankshaft thrust wall is allowed.

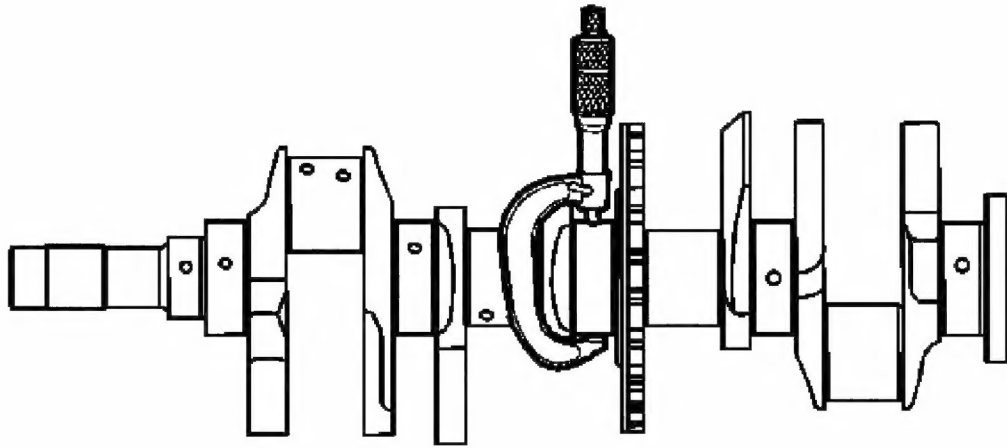


Fig. 8: Checking Size Of Crankshaft Main Journals
Courtesy of GENERAL MOTORS CORP.

7. Check the crankshaft main journals for undersize using an outside micrometer.

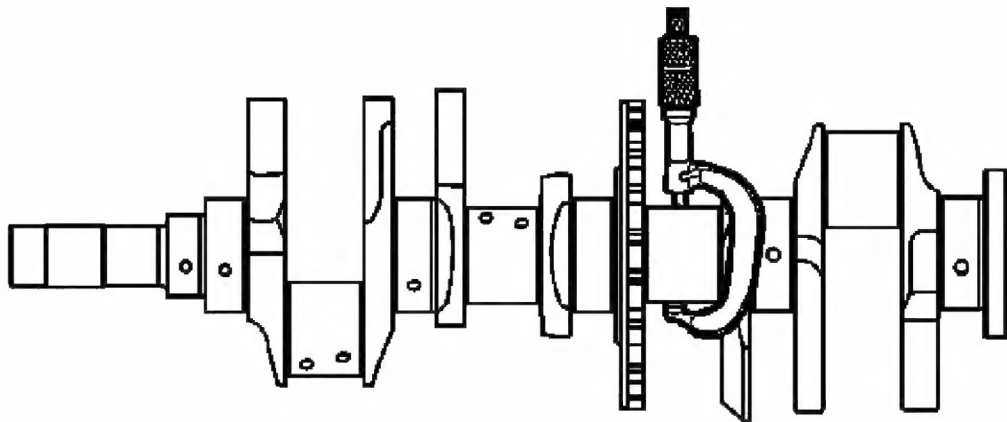


Fig. 9: Checking Crankpins
Courtesy of GENERAL MOTORS CORP.

8. Check the crankpins for undersize using an outside micrometer.
9. Compare your measurements with those listed in the **Engine Mechanical Specifications** . If the crankshaft journals are worn beyond the specified limits, the

crankshaft must be replaced. Crankshaft machining is not allowed and there are no undersized bearings available for service.

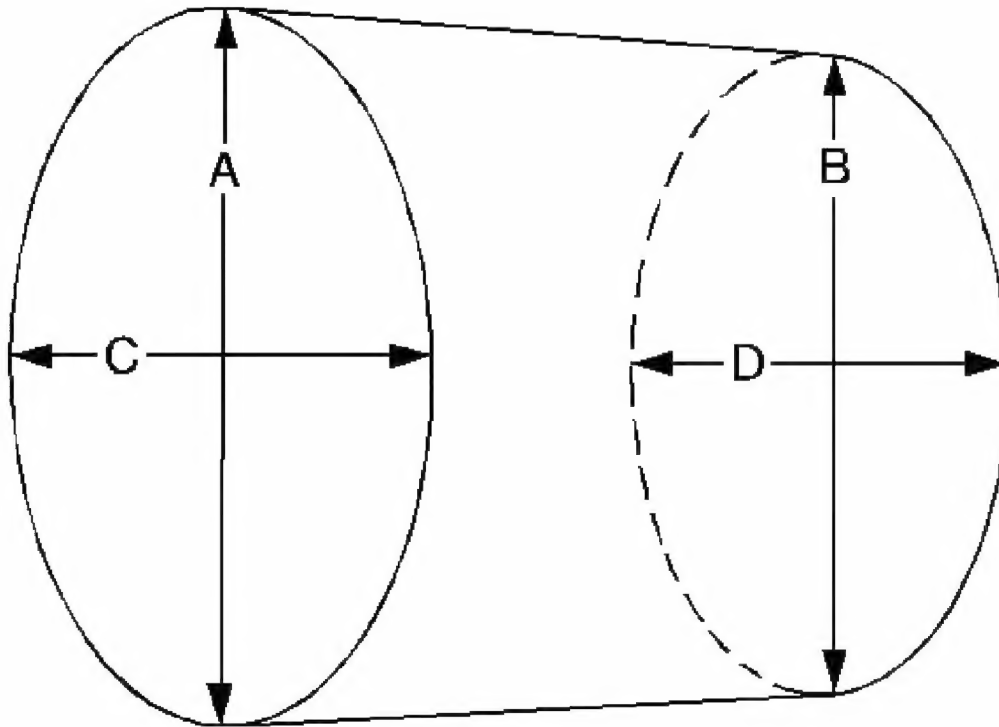


Fig. 10: Identifying Out-Of-Round Measurements
Courtesy of GENERAL MOTORS CORP.

10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
 1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
 2. Measure the journal in two new locations exactly 90 degrees from the first points. Call these points C and D.
 3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
 4. The out-of-round should not exceed 0.005 mm (0.00020 in) maximum.
 5. If the specifications are exceeded, replace the crankshaft.
11. Measure the main bearing and crankpin journals for taper using the following procedure:
 1. Using an outside micrometer, measure the journal at the extreme front (A) and rear

- (B) of the journal parallel to the crankshaft centerline.
2. Subtract the smallest from the largest measurement. The result will be the journal taper.
 3. If the main bearing journal taper exceeds 0.008 mm (0.00032 in), replace the crankshaft.
 4. If the crankpin journal taper exceeds 0.008 mm (0.00032 in), replace the crankshaft.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the crankshaft balancer in solvent that is compatible with the rubber.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the crankshaft balancer with compressed air.

INSPECTION PROCEDURE

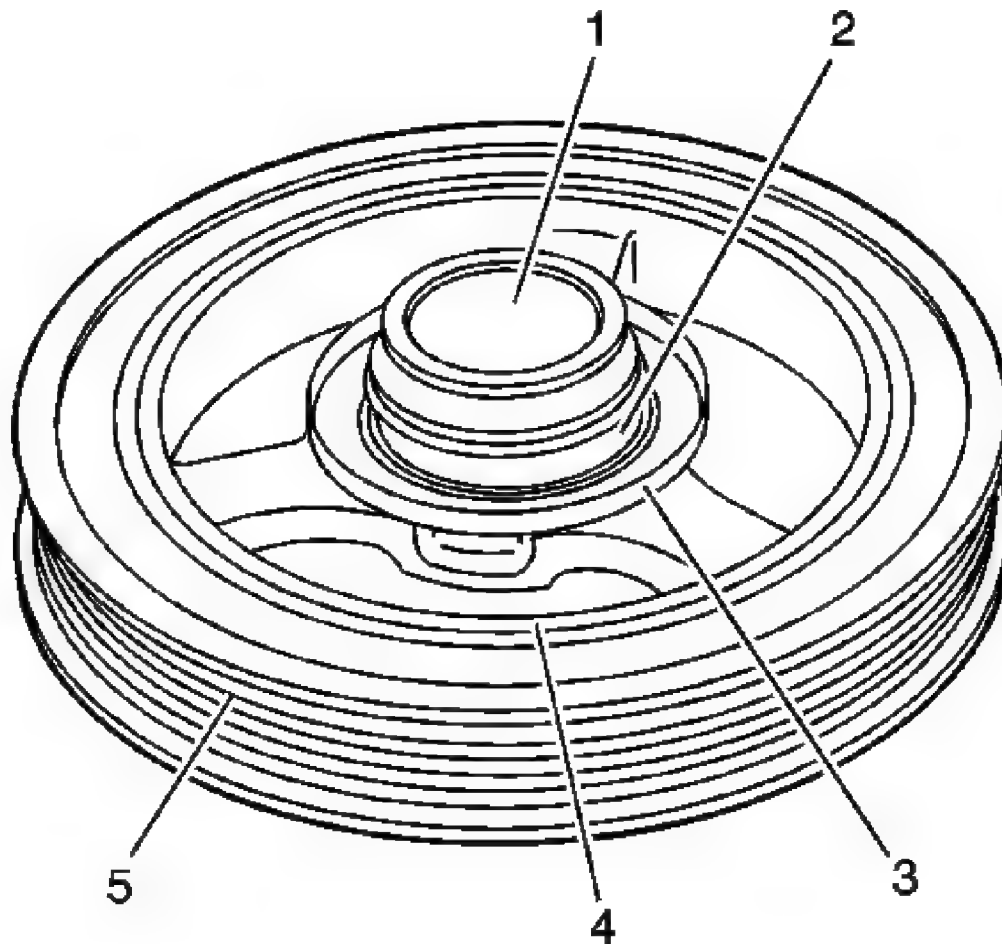


Fig. 11: Inspection Of Crankshaft Balancer Components
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft balancer for the following:
 - Worn or damaged hub-to-crankshaft surface (1)
 - Worn, grooved or damaged hub seal surface (2). A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
 - Bent, damaged or missing crankshaft front oil seal shield (3)
 - Worn, chunking or deteriorated rubber between the hub and pulley (4)
 - Damaged drive belt ribs (5)
2. Repair or replace the crankshaft balancer as necessary.

ENGINE FLYWHEEL CLEANING AND INSPECTION

CLEANING PROCEDURE

IMPORTANT: In order to maintain the proper component balance, contact surface taper and heat transfer, manual transmission flywheels are NOT to be machined.

1. Clean the engine flywheel in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION. .

2. Dry the engine flywheel with compressed air.

INSPECTION PROCEDURE

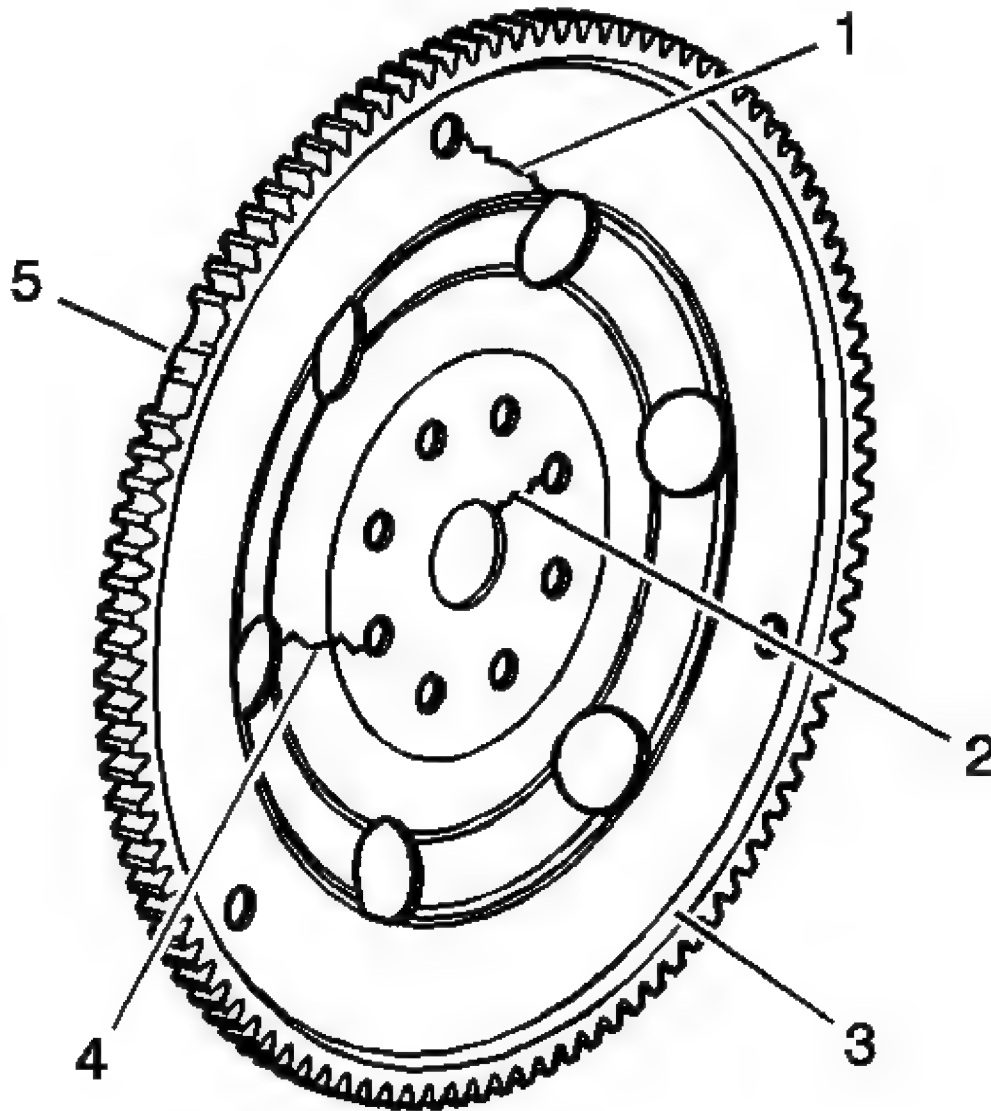


Fig. 12: View Of Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel for the following conditions:
 - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 4)

IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a

new engine flywheel.

- Cracks at welded areas that retain the ring gear onto the engine flywheel (3)
- Damaged or missing ring gear teeth (5)

2. Replace the engine flywheel as necessary.

PISTON AND CONNECTING ROD DISASSEMBLE

TOOLS REQUIRED

EN-46745 Piston Pin Clip Remover/Installer. See **Special Tools** .

DISASSEMBLY PROCEDURE

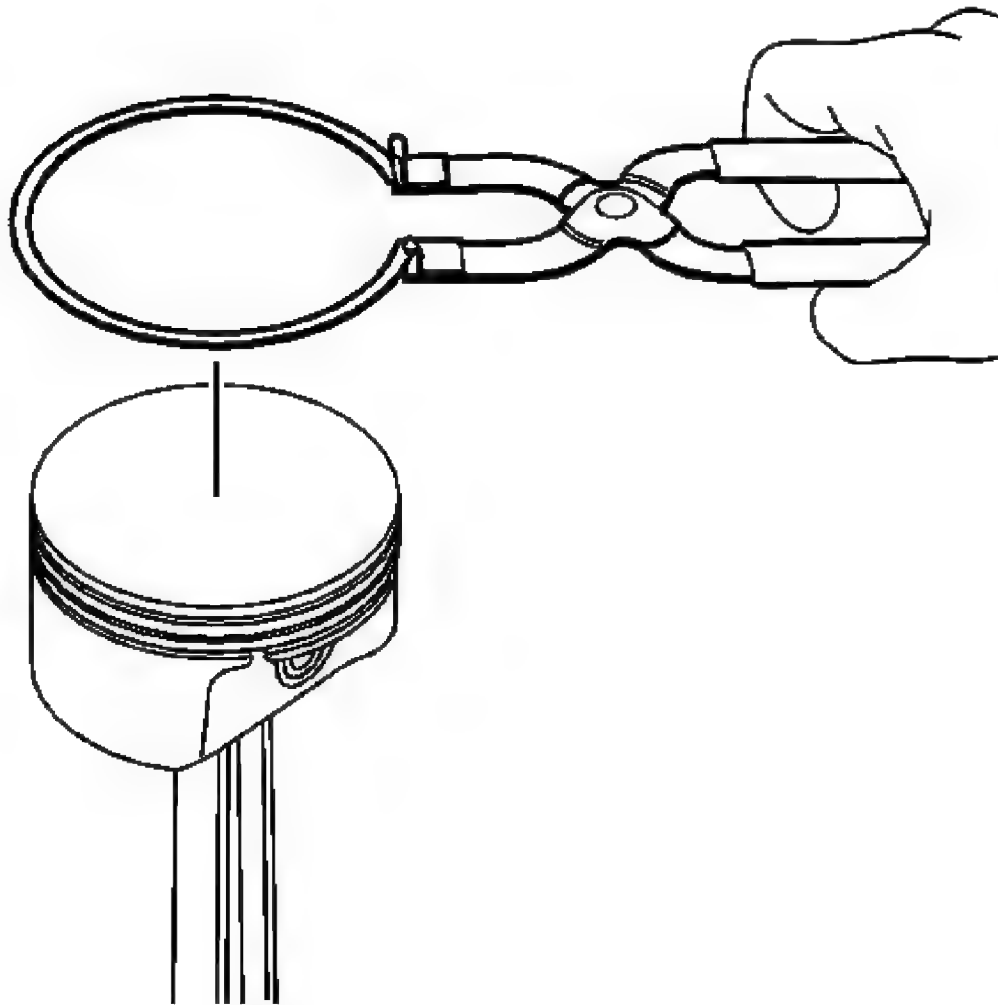


Fig. 13: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.

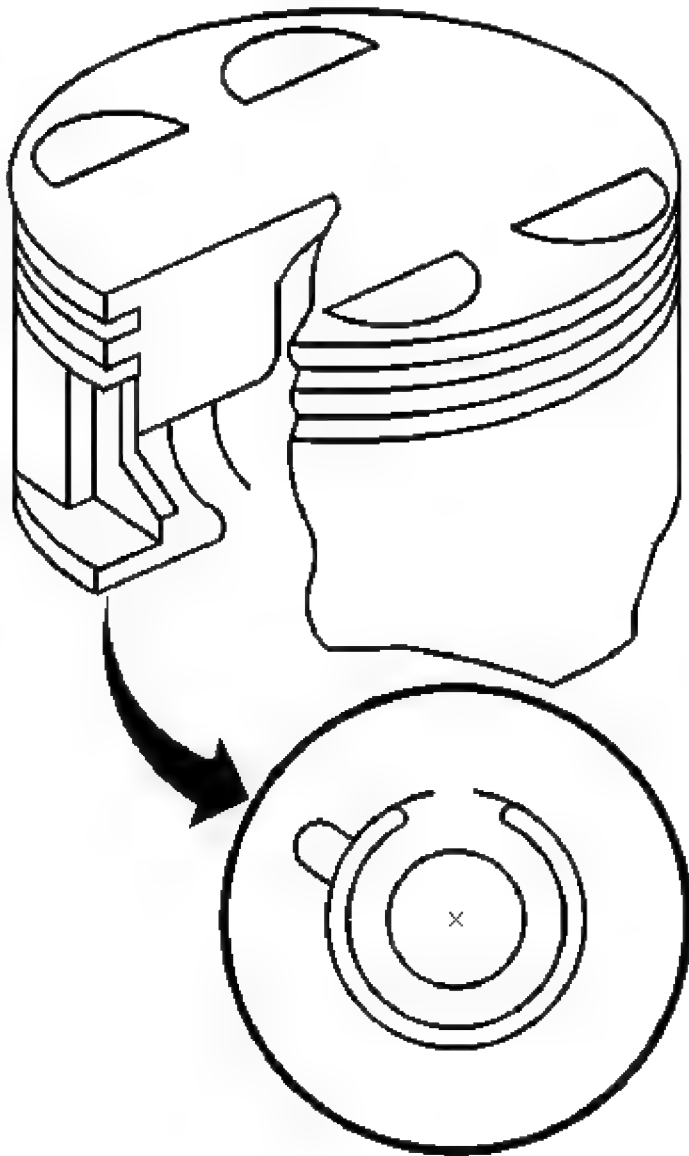


Fig. 14: View Of Piston Pin Retainers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be careful not to nick or gouge the piston or the retaining ring groove with the screwdriver if you plan to reuse the piston.

2. Using the **EN-46745** remove the piston pin retainers by using the removal access notch in

the side of the piston. See **Special Tools** .

3. Discard the old piston pin retainers.

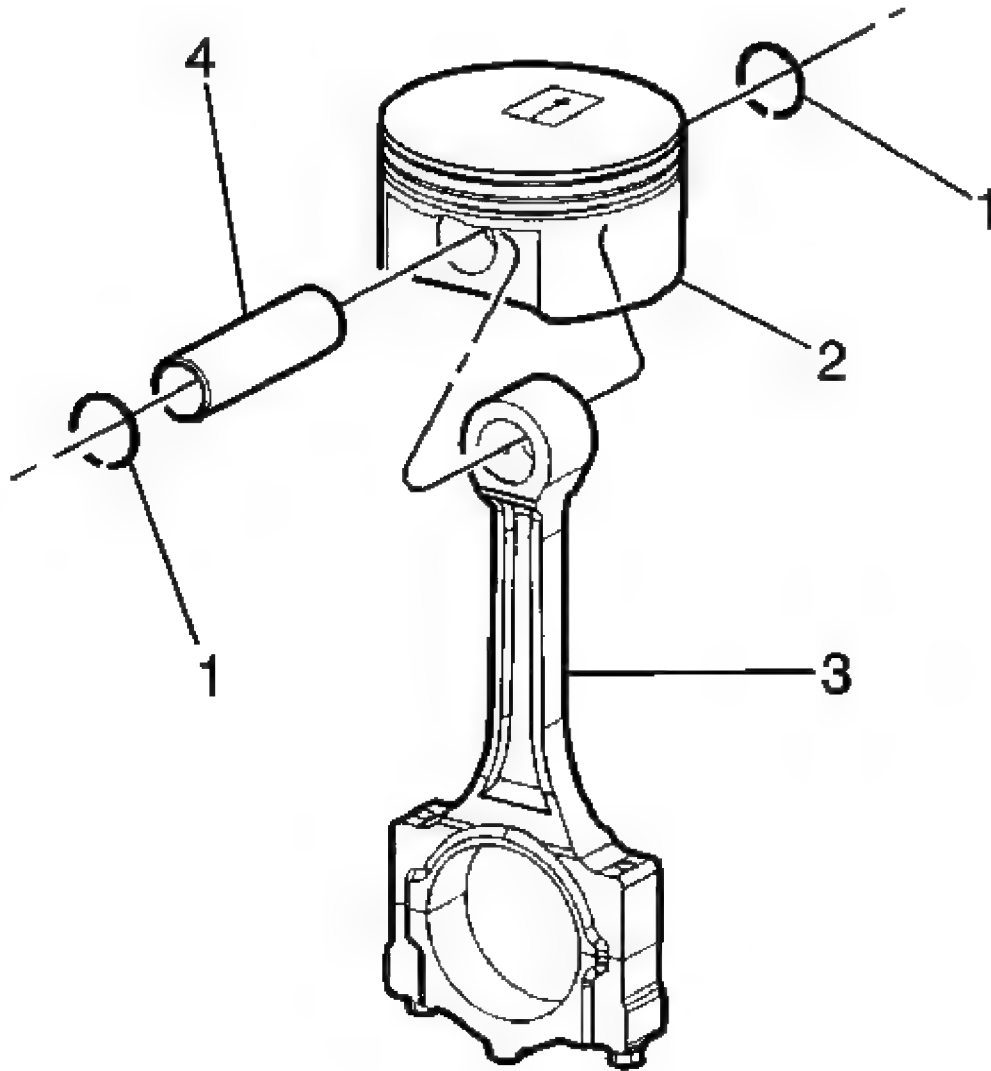


Fig. 15: Exploded View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

4. Slide the piston pin (4) out of the piston. The piston will disconnect from the connecting rod (2).

PISTON, CONNECTING ROD AND BEARING CLEANING AND INSPECTION

PISTON CLEANING PROCEDURE

IMPORTANT: DO NOT wire brush any part of the piston.

- Clean the piston skirts and the pins with a cleaning solvent.
- Clean the piston ring grooves with a groove cleaner. Ensure the oil ring holes and slots are clean.

PISTON INSPECTION PROCEDURE

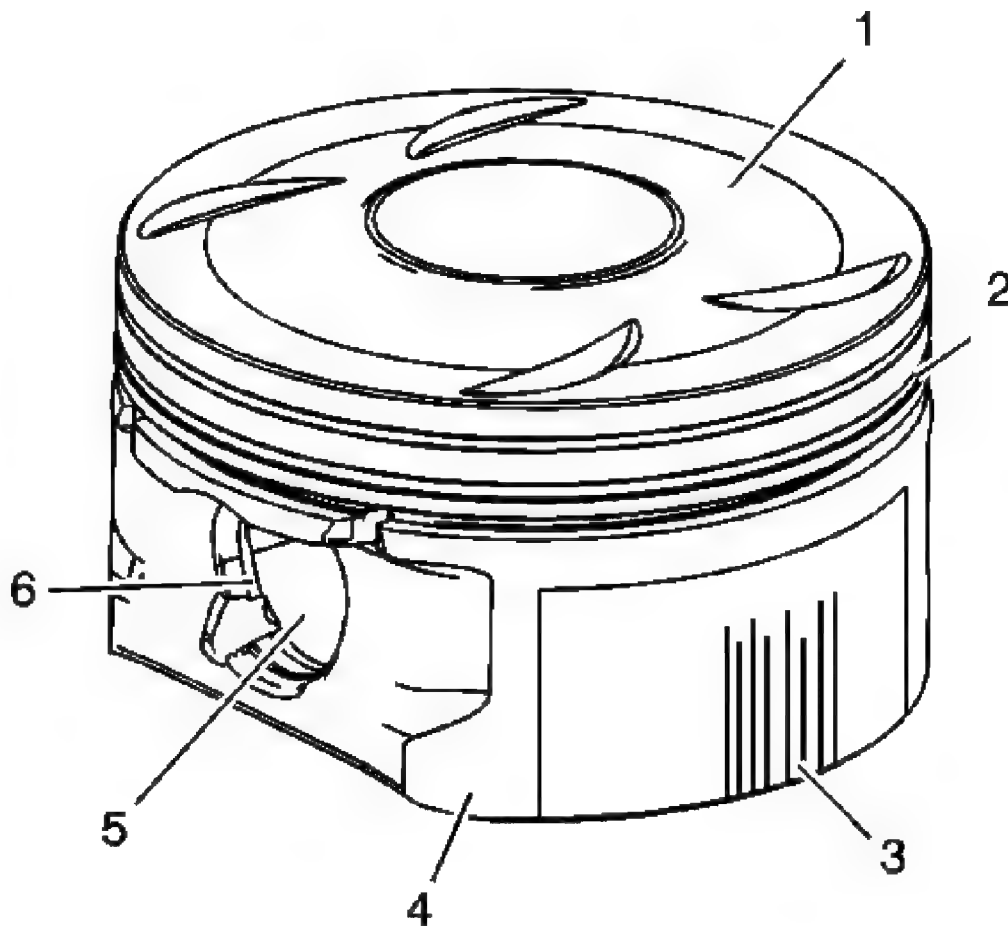


Fig. 16: Inspecting Pistons

Courtesy of GENERAL MOTORS CORP.

1. Inspect the pistons for the following conditions:
 - Eroded areas at the top of the piston (1)

- Ring grooves for nicks, burrs that may cause binding (2)
 - Warped or worn ring lands (2)
 - Scuffed or damaged skirt coating (3)
 - Cracked ring lands, skirts or pin bosses (4)
 - Worn piston pin bores or worn piston pins (5)
 - Piston pin retainer grooves for burrs (6)
2. Replace pistons that show any signs of damage or excessive wear.

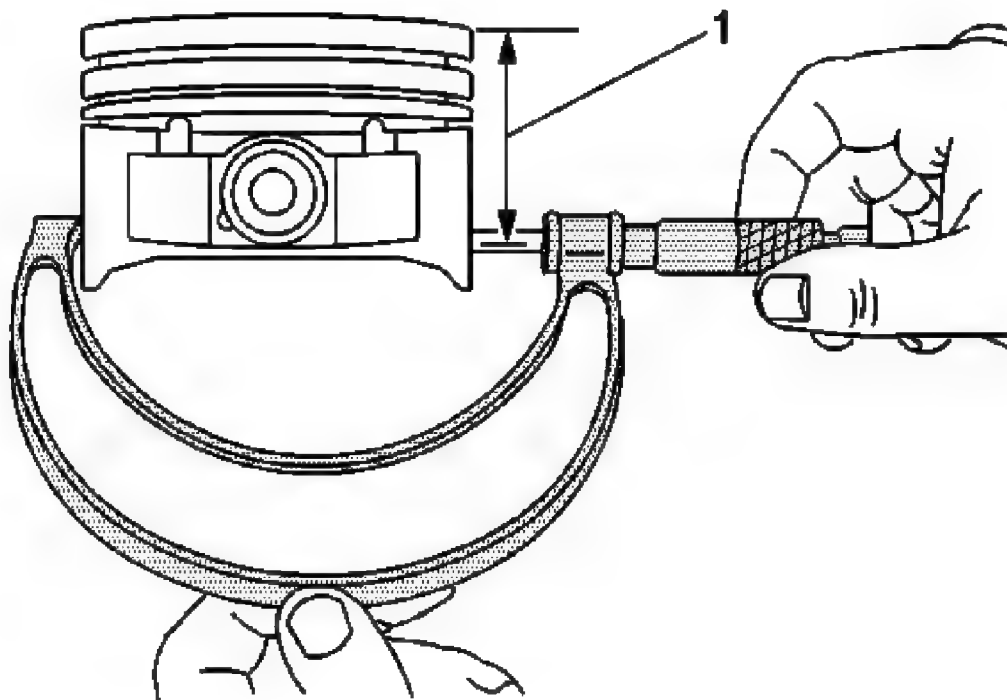
PISTON DIAMETER MEASUREMENT PROCEDURE

Fig. 17: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

1. Using an outside micrometer, measure the width of the piston 40 mm (1.575 in) below the crown (top) of the piston at the thrust surface which is perpendicular to the centerline of the piston pin (1).
2. Compare the measurement to the diameter listed in the **Engine Mechanical Specifications**.
3. You must replace the piston if any of its dimensions are out of specification. There are no

oversized pistons available.

PISTON PIN BORE MEASUREMENT PROCEDURE

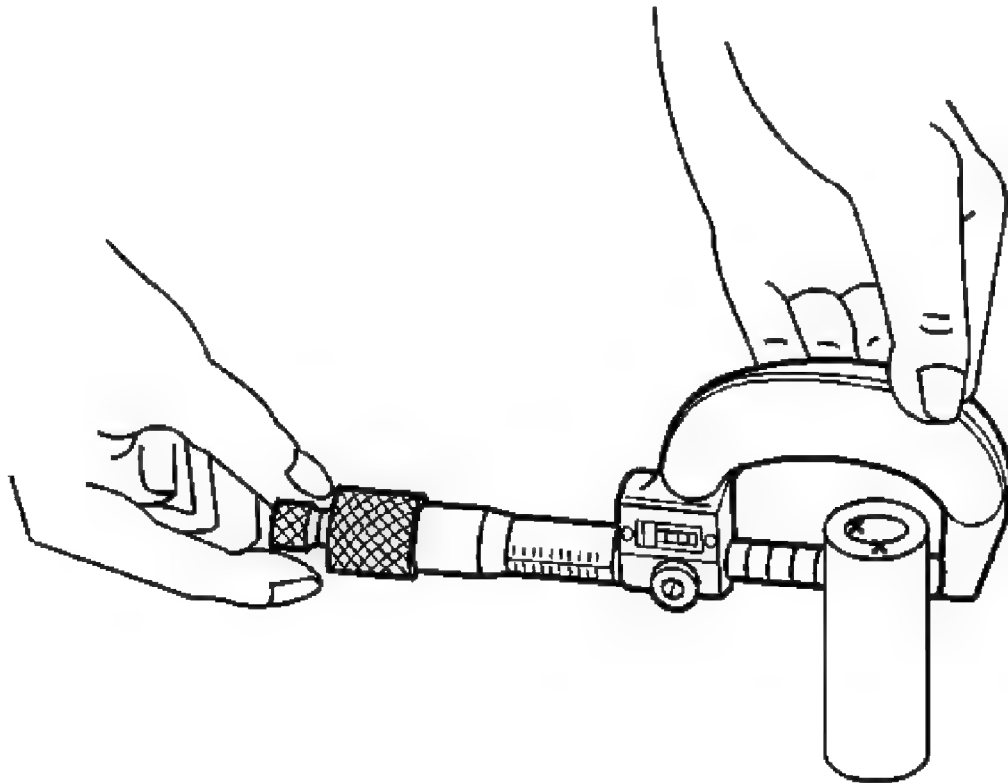


Fig. 18: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

1. Piston pin bores and pins must be free of varnish or scuffing.
2. Use an outside micrometer to measure the piston pin in the piston contact areas.

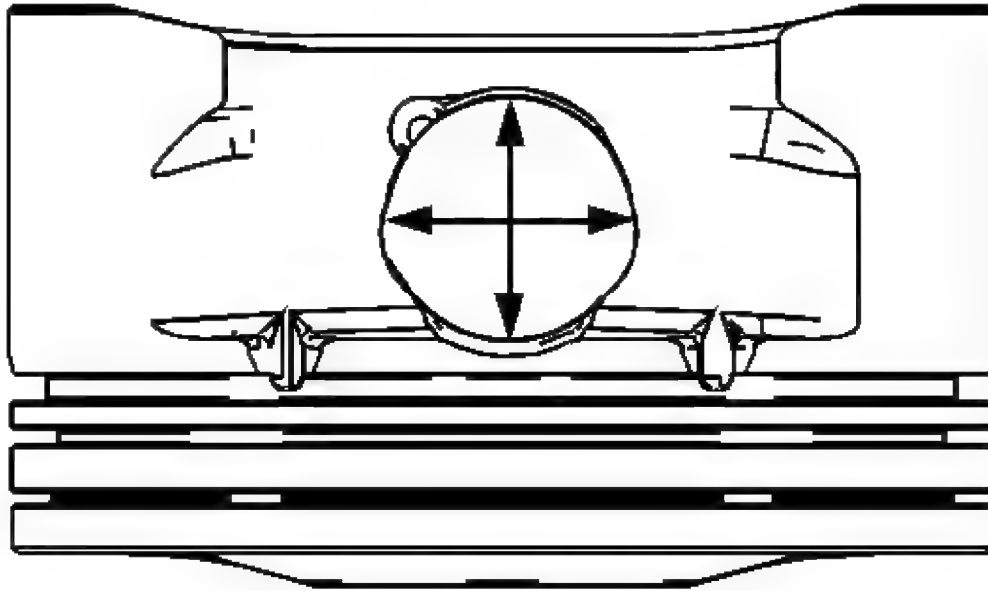


Fig. 19: Measuring Piston Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Using an inside micrometer, measure the piston pin bore.
4. Subtract the measurement of the piston pin bore from the piston pin.
5. Compare the result with the **Engine Mechanical Specifications** .
6. If the clearance is excessive, determine which piece is out of specification and replace as necessary.

PISTON RING END GAP MEASUREMENT PROCEDURE

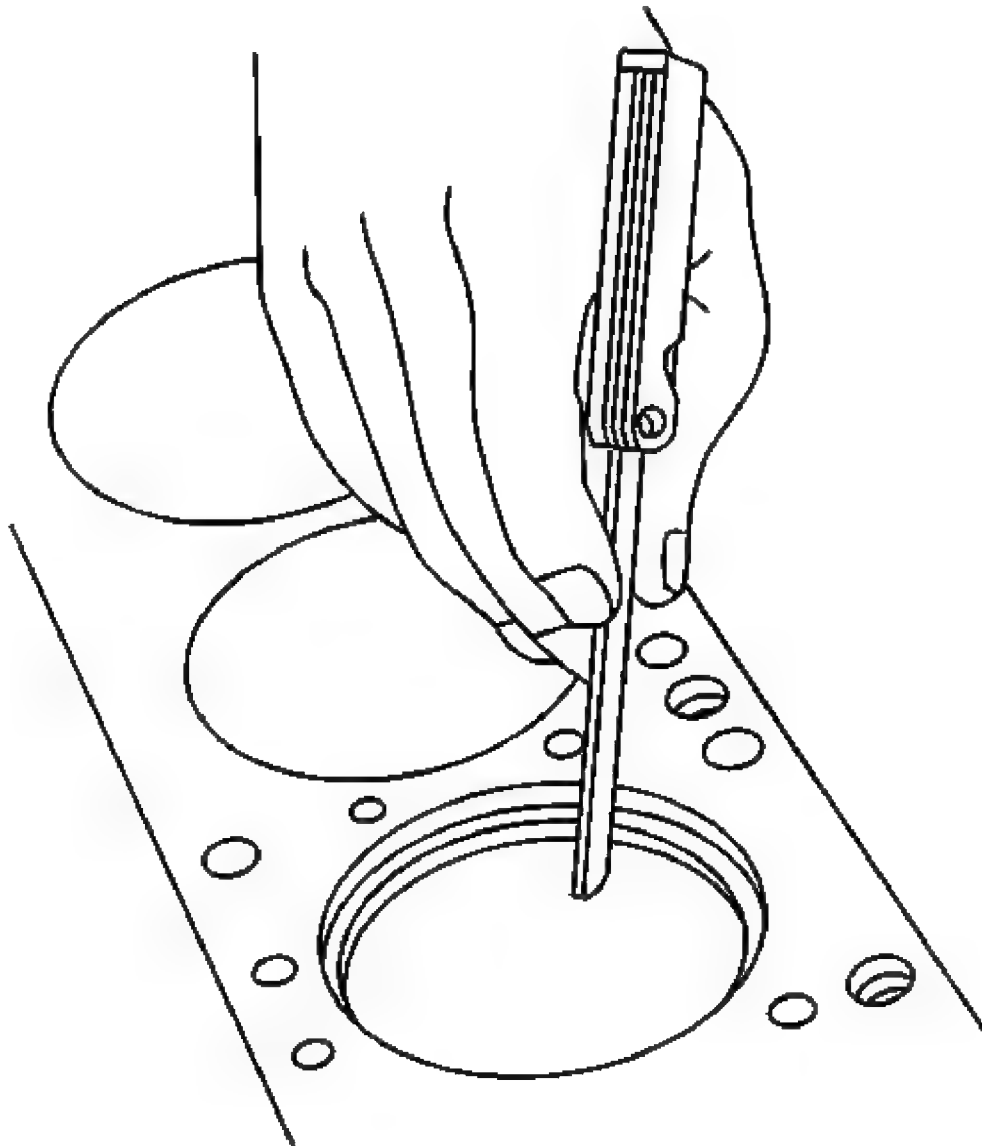


Fig. 20: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

1. Place the piston ring in the area of the bore where the piston ring will travel, approximately 25 mm (1 in) down from the deck surface. Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gages. Compare the measurements with those provided in the **Engine Mechanical Specifications**.
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.

4. Repeat this procedure for all the piston rings.

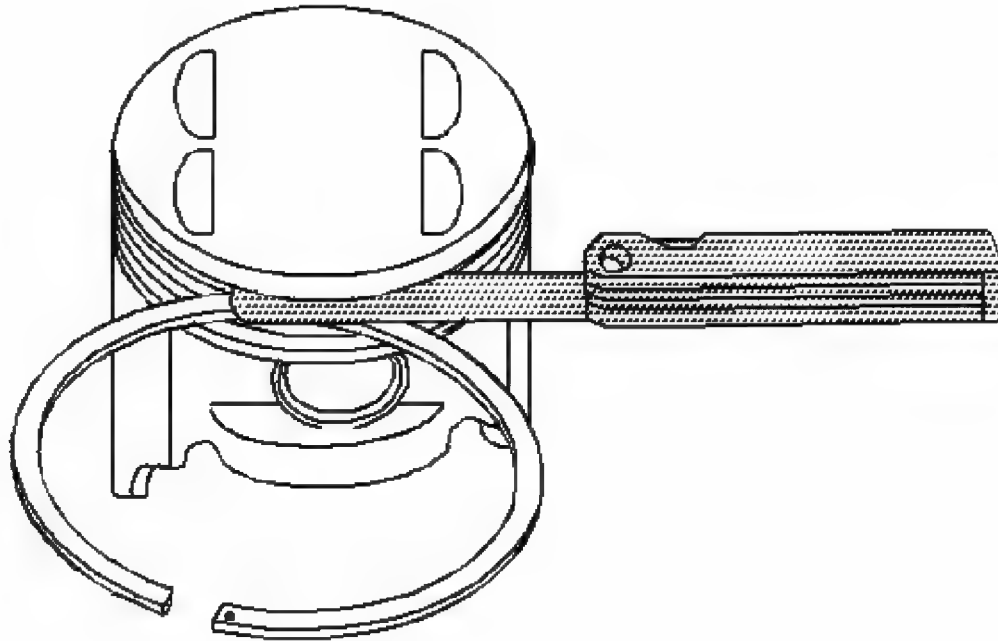
PISTON RING SIDE CLEARANCE MEASUREMENT PROCEDURE

Fig. 21: Checking Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.
2. With the piston ring on the piston, use feeler gages to check side clearance at multiple locations.
3. Compare your measurements with those found in the **Engine Mechanical Specifications** .
4. If the clearance is greater than specifications, replace the piston rings.
5. If new piston rings do not bring the clearance within the specification, the piston must be replaced.

CONNECTING ROD CLEANING PROCEDURE

1. Clean the connecting rods in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.
4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

CONNECTING ROD VISUAL INSPECTION PROCEDURE

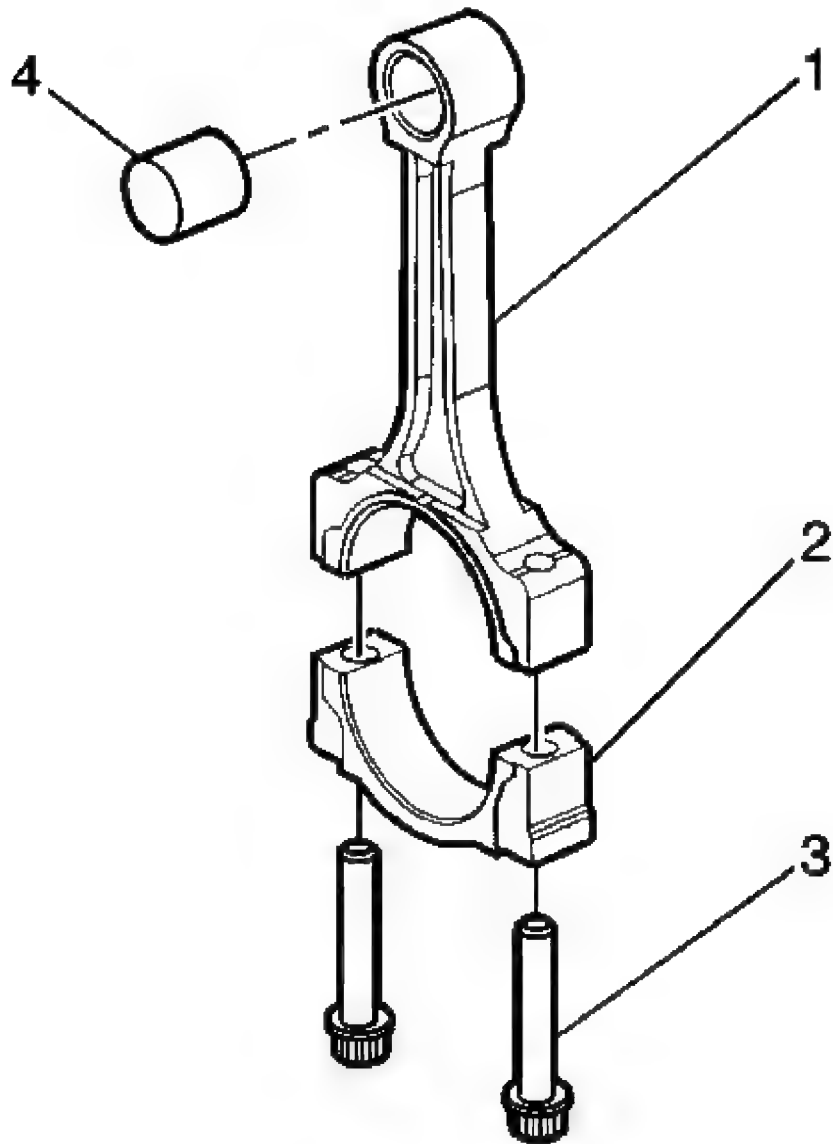


Fig. 22: Inspecting Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

IMPORTANT: DO NOT scrape the rod or rod cap.

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

CONNECTING ROD MEASUREMENT PROCEDURE

Piston Pin End

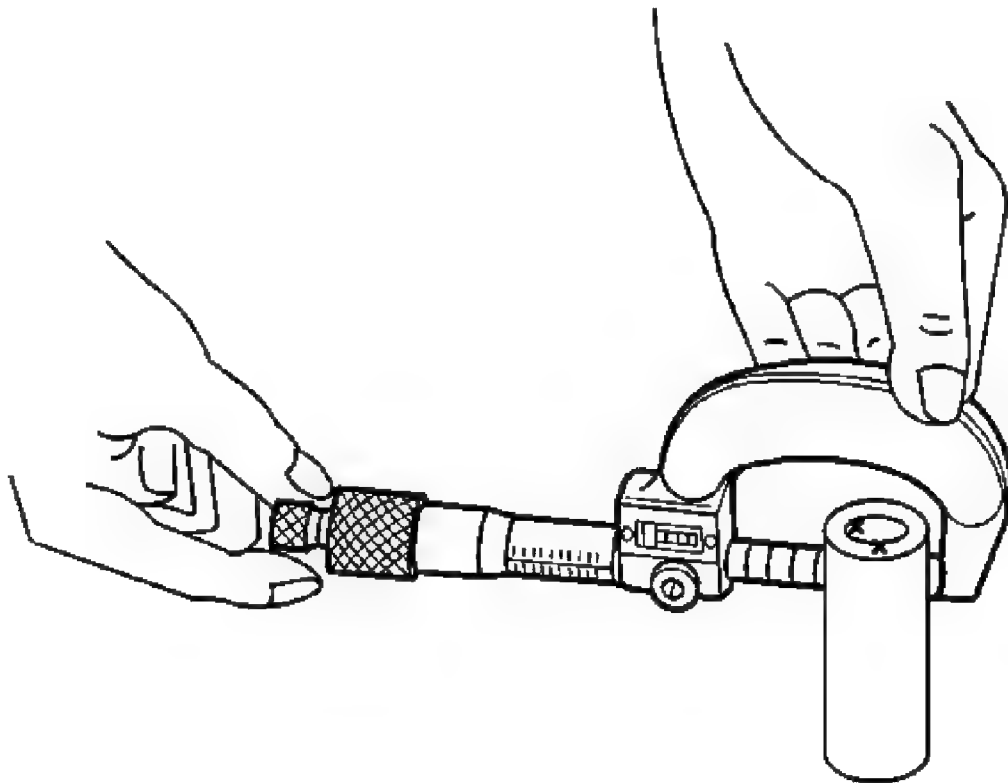


Fig. 23: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.

1. Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact.

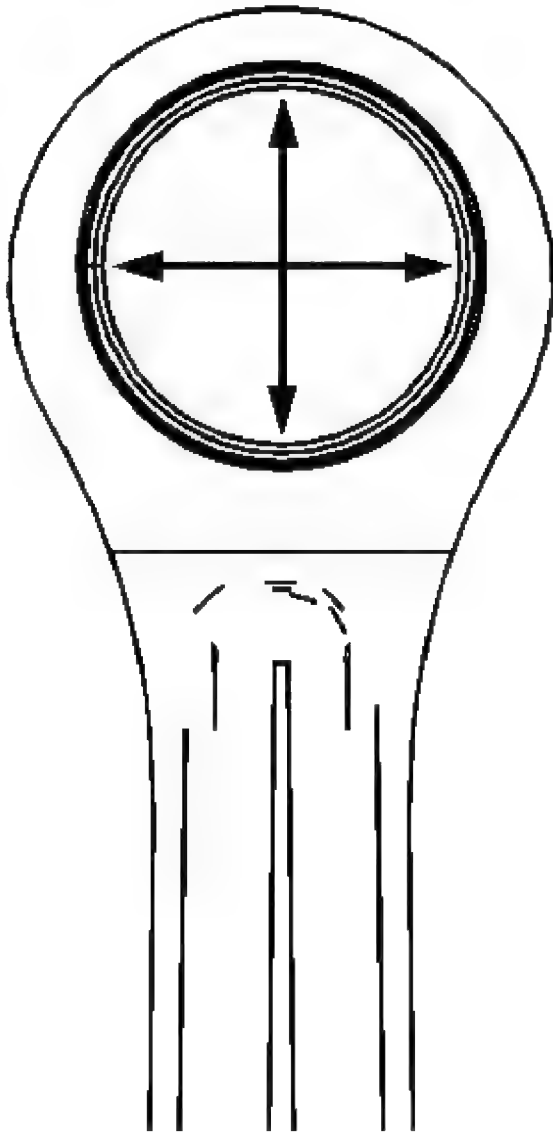


Fig. 24: Checking Connecting Rod Piston Pin Bore Dimensions
Courtesy of GENERAL MOTORS CORP.

2. Using an inside micrometer, measure the connecting rod piston pin bore.
3. Subtract the piston pin diameter from the piston pin bore.
4. Compare the clearance measurements with the **Engine Mechanical Specifications** .
5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End

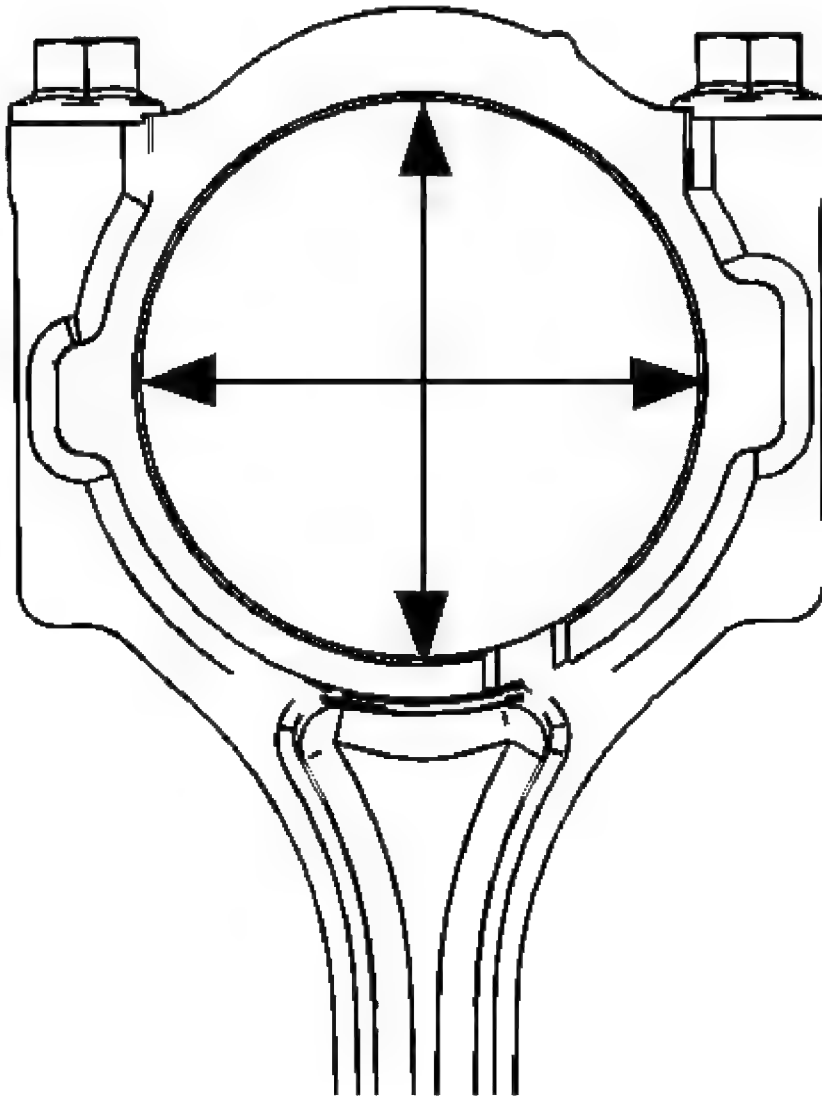


Fig. 25: Measuring Connecting Rod Crankshaft Bearing Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.
2. Compare the bore measurements with the **Engine Mechanical Specifications** .

3. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

PISTON AND CONNECTING ROD ASSEMBLE

TOOLS REQUIRED

EN-46745 Piston Pin Clip Remover/Installer. See Special Tools .

PISTON AND PISTON PIN INSTALLATION PROCEDURE

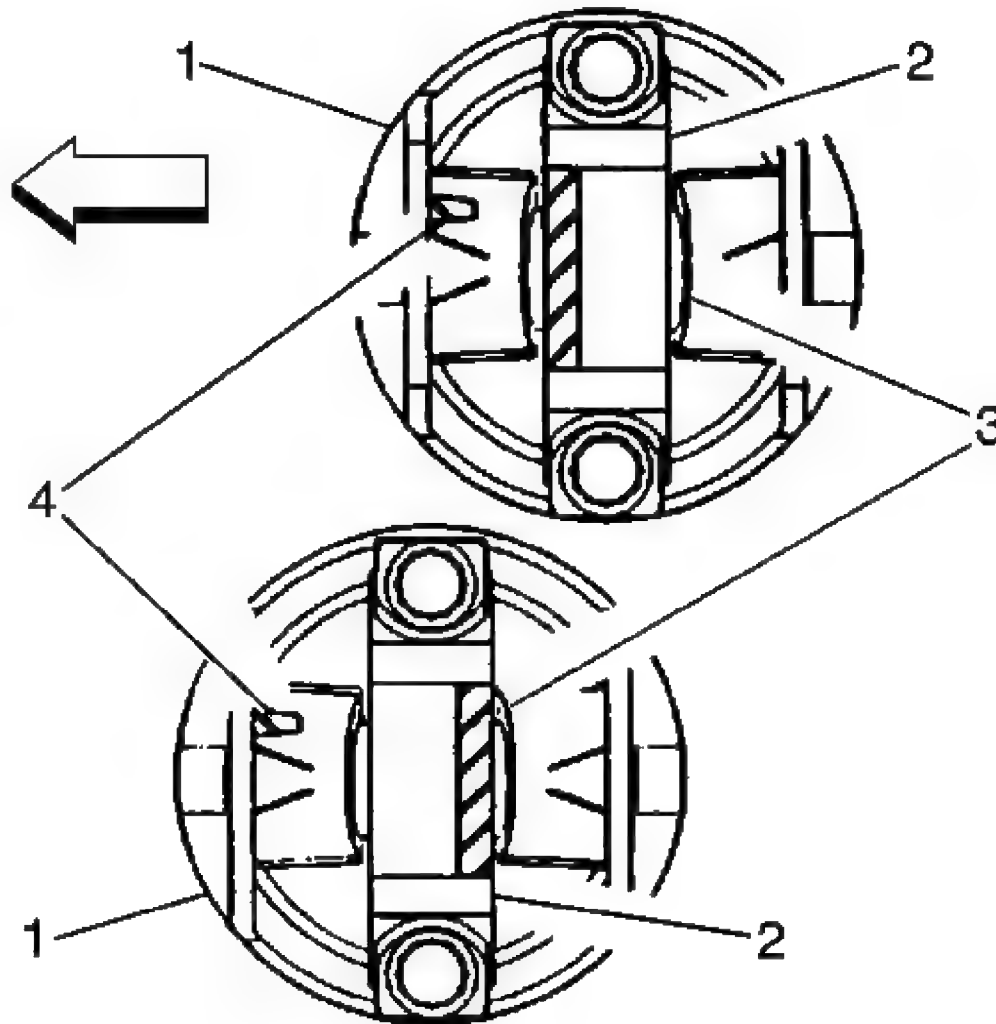


Fig. 26: Identifying Piston & Connecting Rod Locating Marks
Courtesy of GENERAL MOTORS CORP.

1. Properly orient the piston (1) on the connecting rod (2) as follows:
 - The locating mark (4) cast into the underside of the piston should point towards the front of the engine.
 - The locating notch (3) on the connecting rod cap should be pointing towards the rear of the engine on odd-numbered cylinders and towards the front of the engine on even-numbered cylinders.
2. Lubricate the piston pin bores in the piston and connecting rod with GM prelube lubricant GM P/N 1052367 (Canadian P/N 992869) or equivalent.

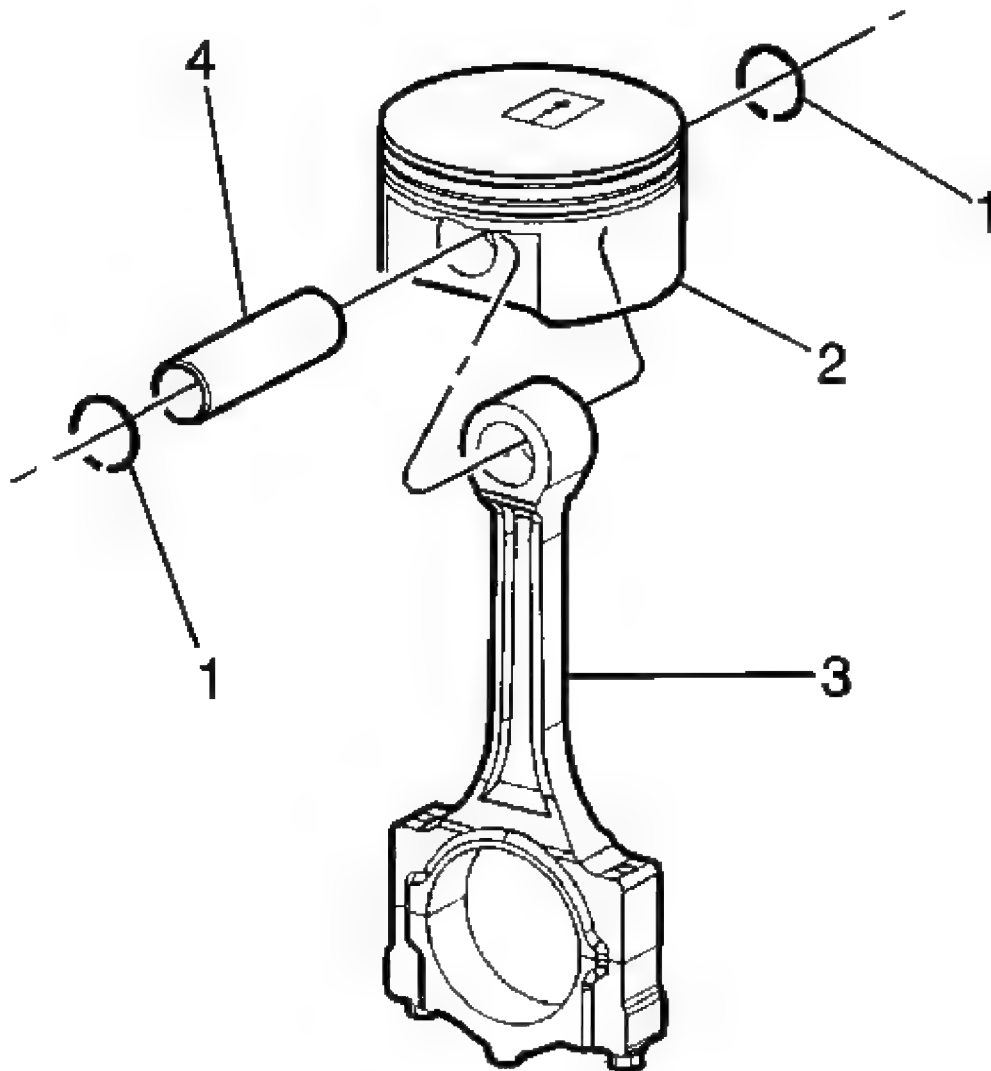


Fig. 27: Exploded View Of Piston & Connecting Rod Assembly

Courtesy of GENERAL MOTORS CORP.

3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin (4) into the piston and the connecting rod (3).

IMPORTANT: New piston pin retainers must be used. Never reuse the piston pin retainers.

5. Install NEW piston pin retainers (1) using the **EN-46745** . See **Special Tools** .
6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

PISTON RING INSTALLATION PROCEDURE

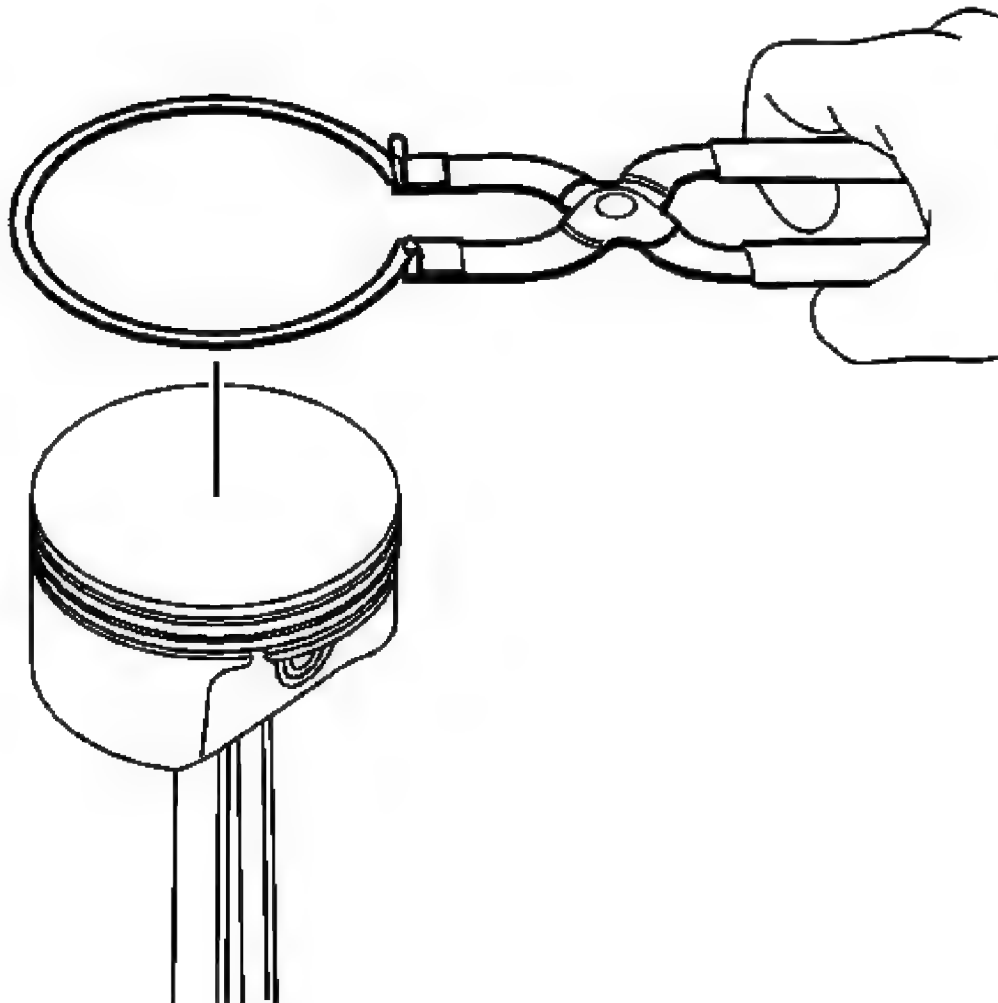


Fig. 28: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

1. Install the piston rings using a piston ring installer.

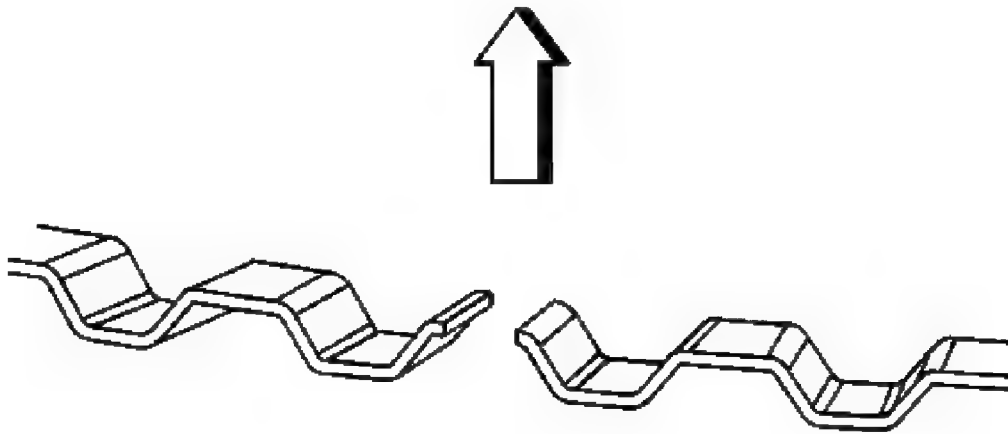


Fig. 29: Aligning Oil Control Ring Expander
Courtesy of GENERAL MOTORS CORP.

2. Properly orient the oil control ring expander as shown before installation. The ends of the expander must be facing toward the top of the piston.

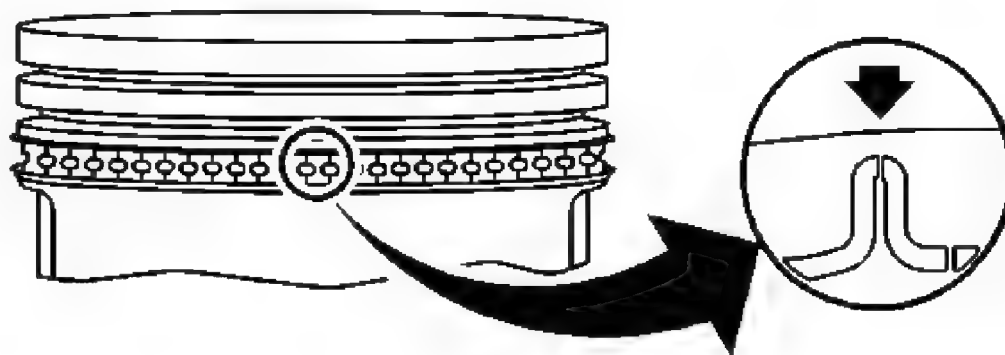


Fig. 30: View Of Lower Oil Control Piston Ring Spacer
Courtesy of GENERAL MOTORS CORP.

3. Install the oil control piston ring spacer onto the piston.

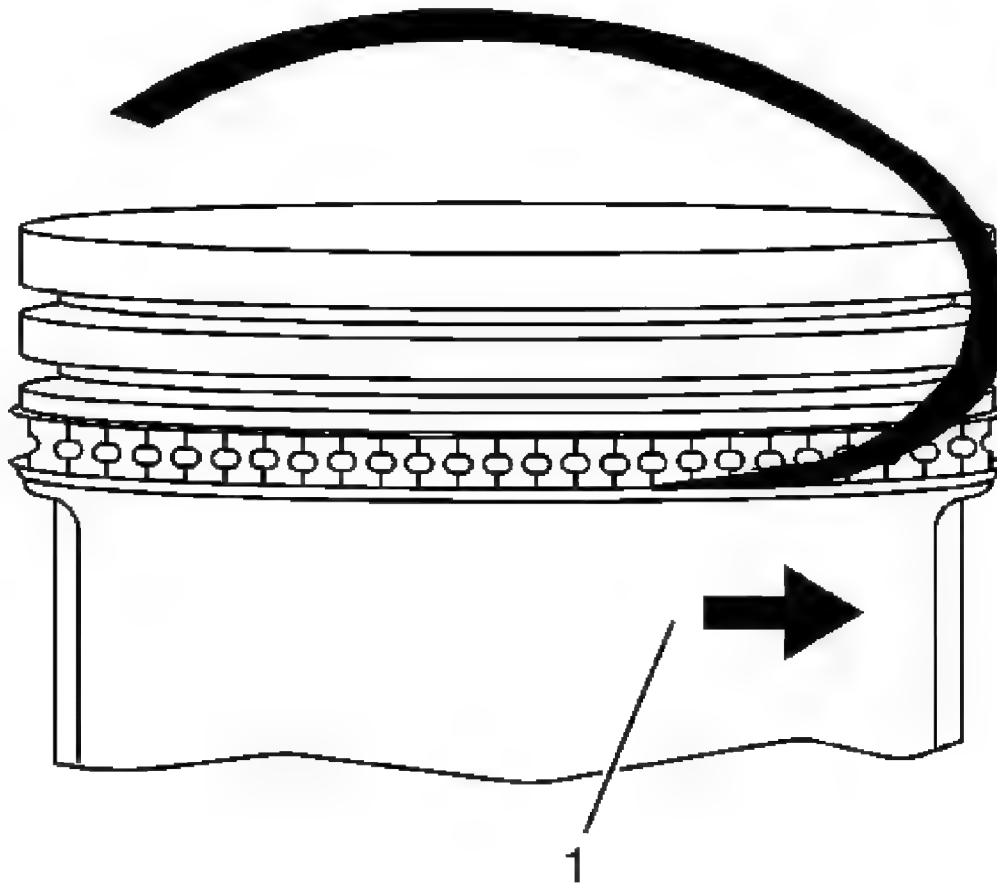


Fig. 31: View Of Lower Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

4. Install the lower oil control piston ring onto the piston (1).

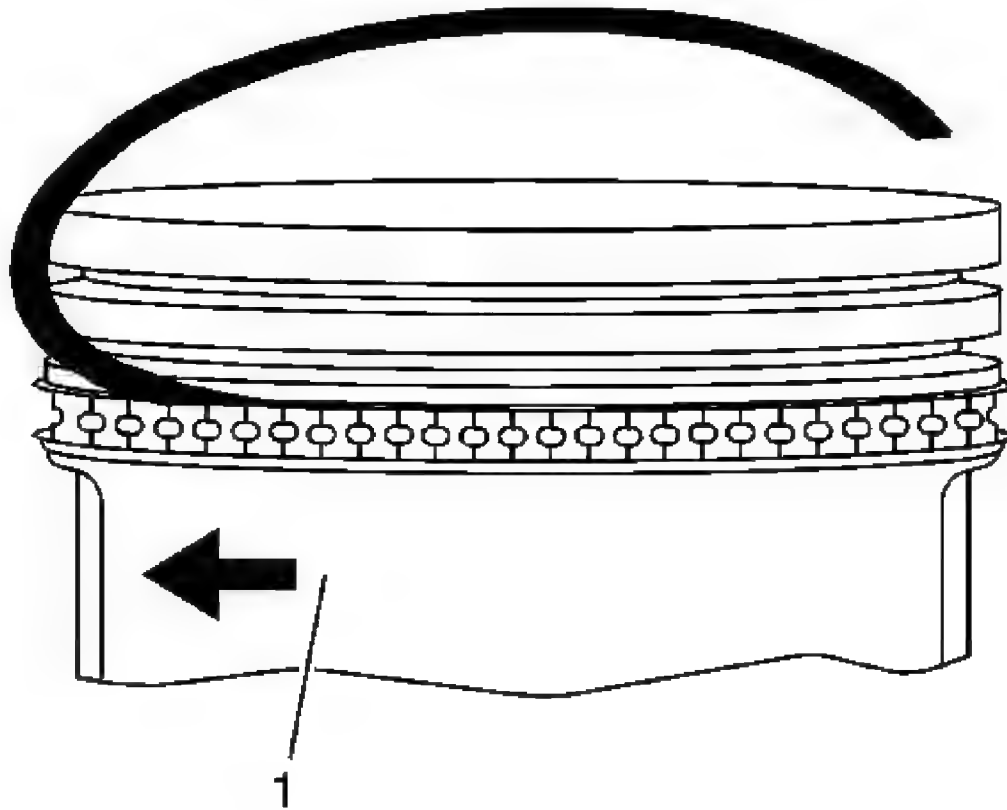


Fig. 32: View Of Upper Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

5. Install the upper oil control piston ring onto the piston (1).

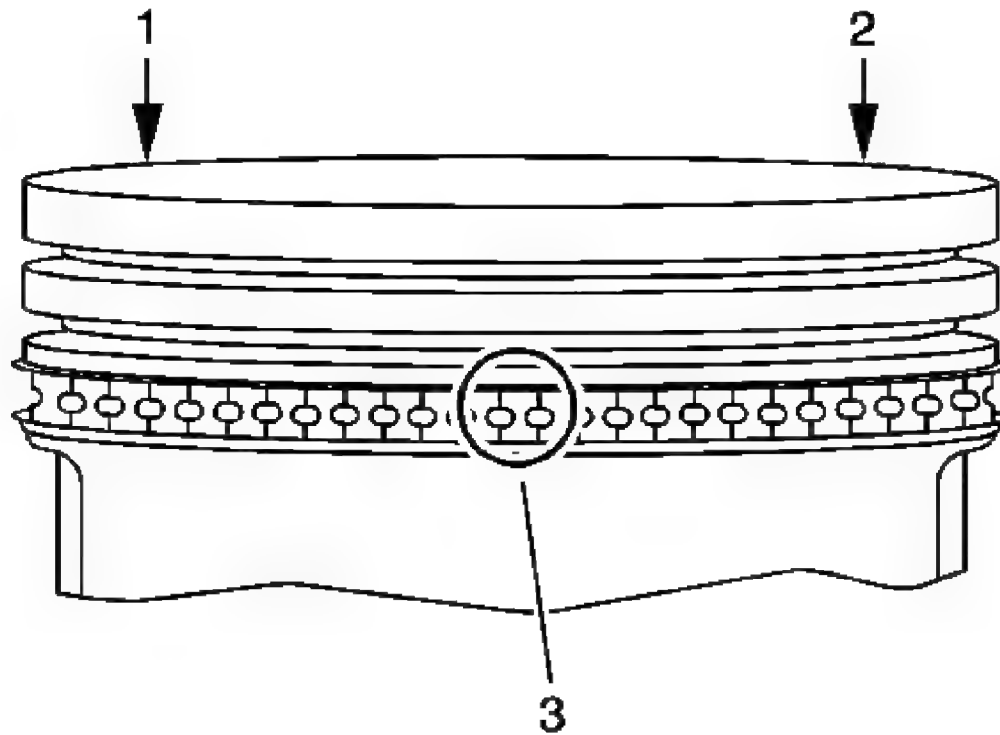


Fig. 33: View Of Oil Control Piston Rings
Courtesy of GENERAL MOTORS CORP.

6. Space the oil control piston ring end gaps (1, 2) a minimum of 90 degrees apart.

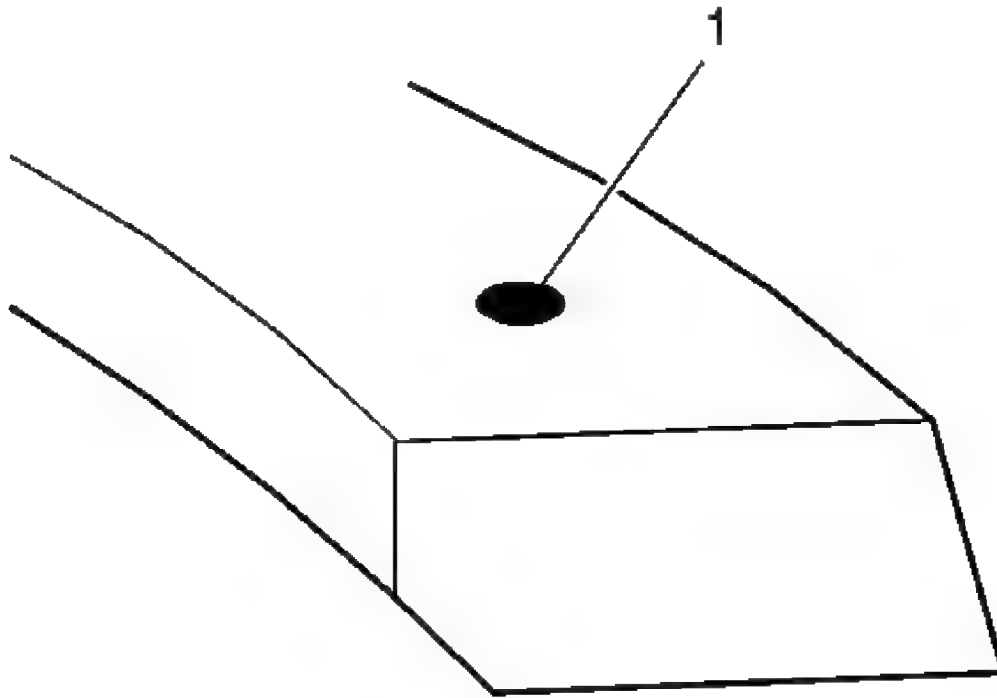


Fig. 34: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

7. Install the lower compression piston ring onto the piston (1).

The mark on the side of the piston ring should face the top of the piston.

8. Install the upper compression piston ring onto the piston.

The top compression ring may be installed with either side up.

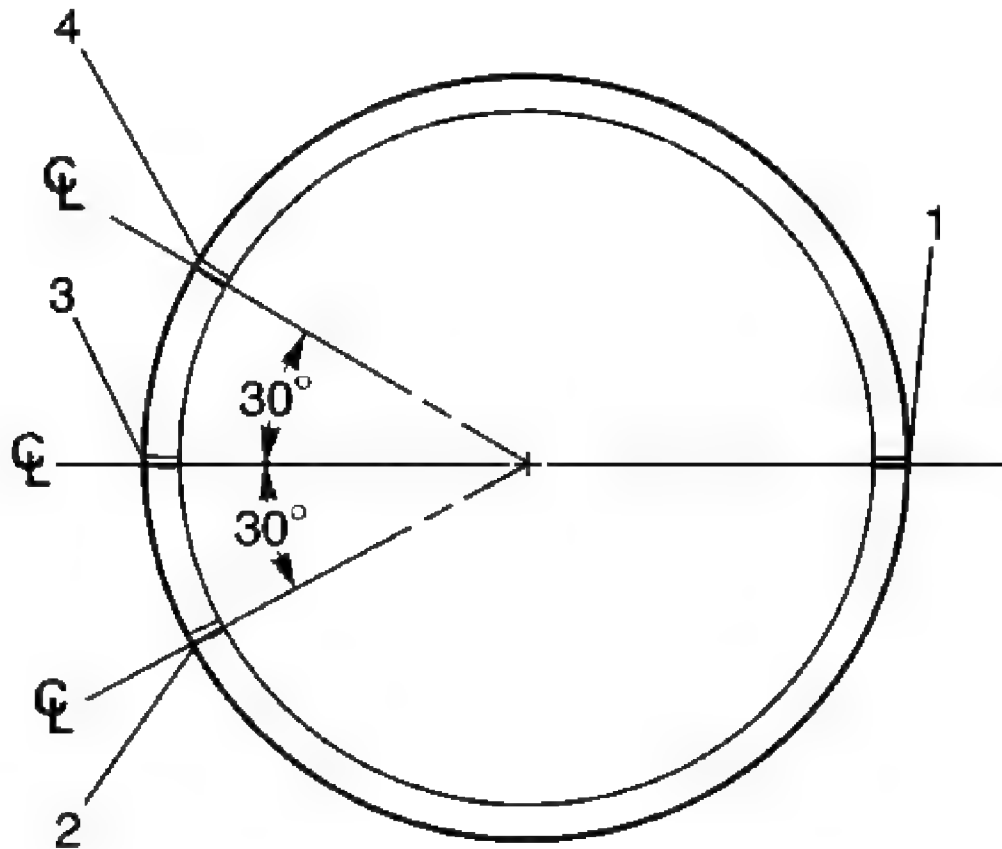


Fig. 35: Identifying Proper Oil Control Ring Gap Positioning
Courtesy of GENERAL MOTORS CORP.

9. Once the rings are installed, set the ring gaps for the oil control, second and top rings in the positions shown:
 1. Oil control ring expander and second compression ring gap position 1.
 2. Upper oil control ring gap position 2.
 3. Top compression ring gap position 3.
 4. Lower oil control ring gap position 4.

CONNECTING ROD BEARING INSTALLATION PROCEDURE

IMPORTANT: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.

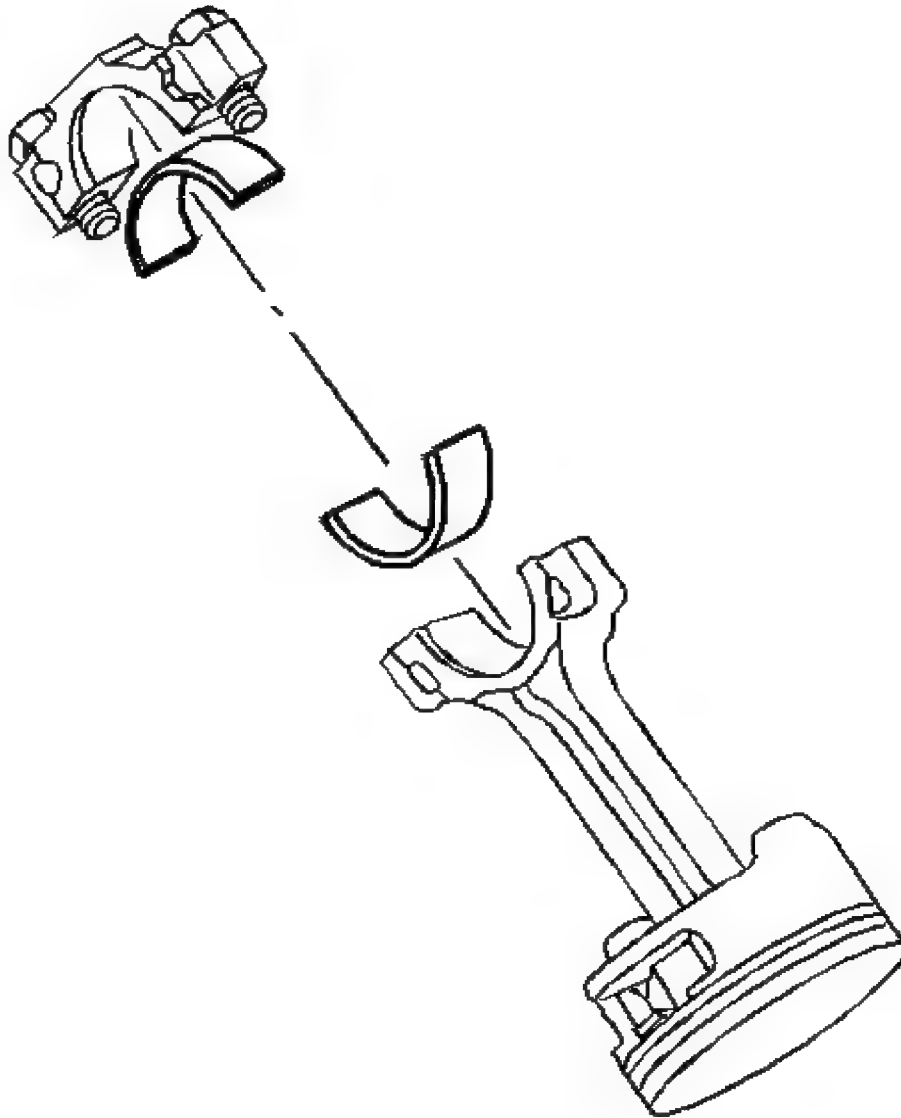


Fig. 36: View Of Piston, Connecting Rod, Bearing Cap, Bearing Halves & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Clean all the oil from behind the connecting rod bearing halves.
3. Install new upper connecting rod bearings into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.

4. Install new lower connecting rod bearings into position in the connecting rod cap. Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

CAMSHAFT INTERMEDIATE DRIVE SHAFT CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the camshaft intermediate drive shaft in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the camshaft intermediate drive shaft with compressed air.

INSPECTION PROCEDURE

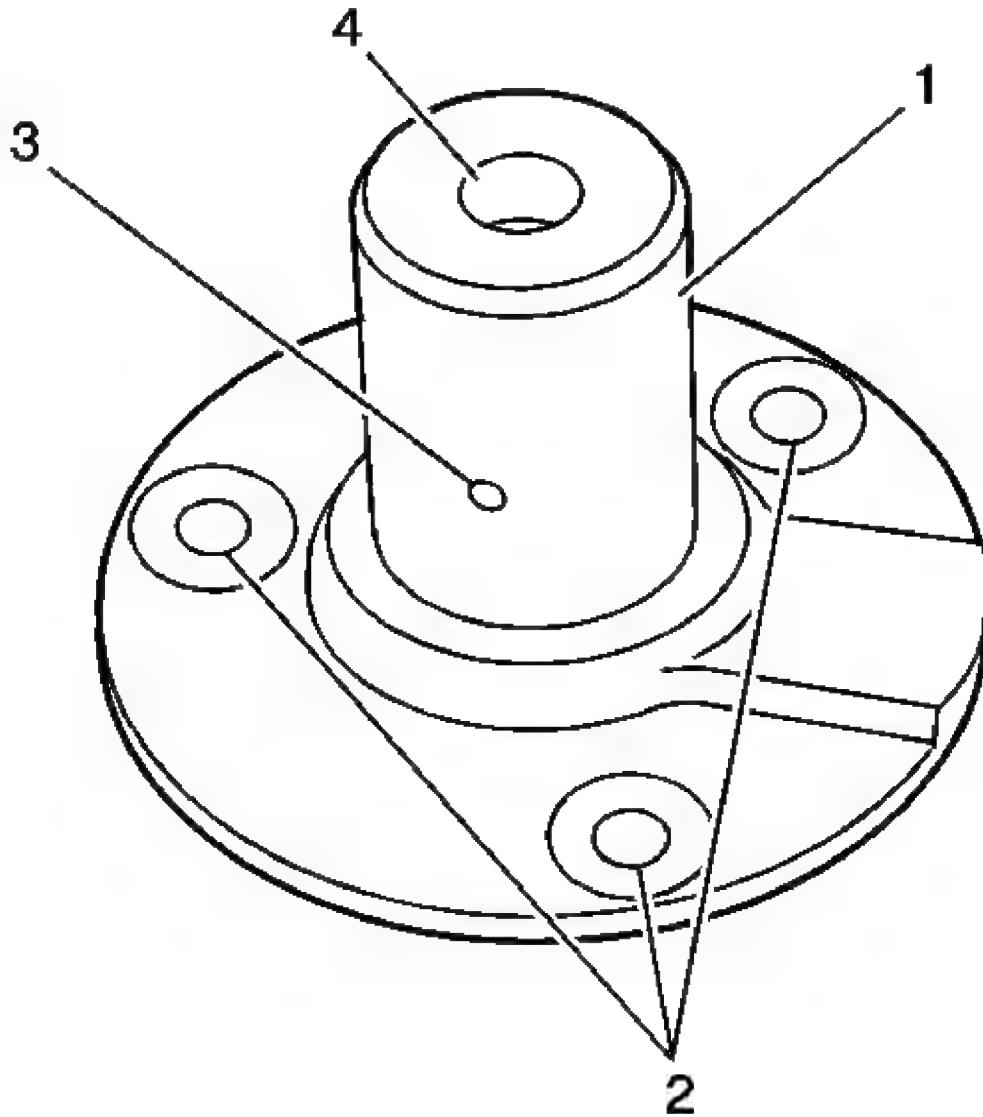


Fig. 37: Inspecting Camshaft Intermediate Drive Shaft
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft intermediate drive shaft for the following:
 - Worn or damaged hub-to-camshaft intermediate drive shaft sprocket bearing surface (1)
 - Cracks or damage to the camshaft intermediate drive shaft fastener holes (2)
 - Restrictions to the oil passage (3)
 - Damaged or stripped thread (4)

2. Repair or replace the camshaft intermediate drive shaft as necessary.

CYLINDER HEAD DISASSEMBLE

TOOLS REQUIRED

- **J 8062** Valve Spring Compressor - Head Off. See **Special Tools** .
- **J 38821** Valve Spring Compressor Adapter. See **Special Tools** .
- **J 38820** Valve Stem Seal Installer. See **Special Tools** .
- **J-43059-A** Valve Retainer Remover/Installer. See **Special Tools** .

DISASSEMBLY PROCEDURE

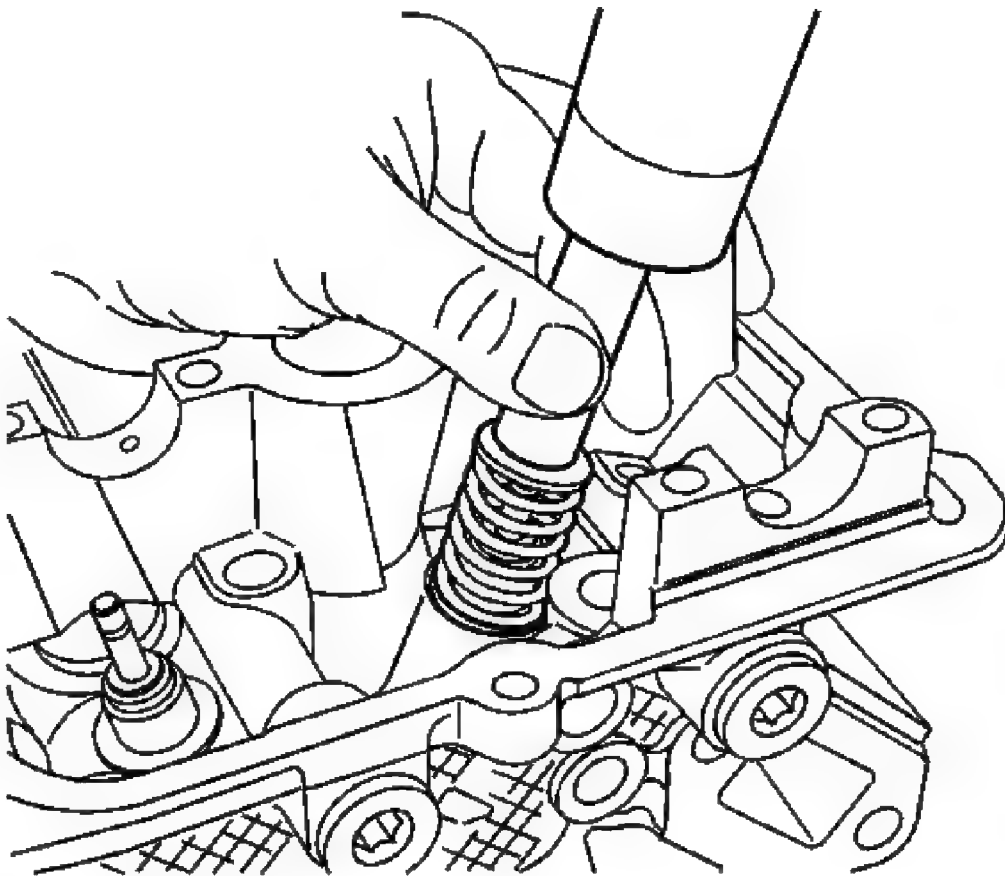


Fig. 38: Tapping On Valve Spring Retainer
Courtesy of GENERAL MOTORS CORP.

1. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer in order to loosen the valve keepers.

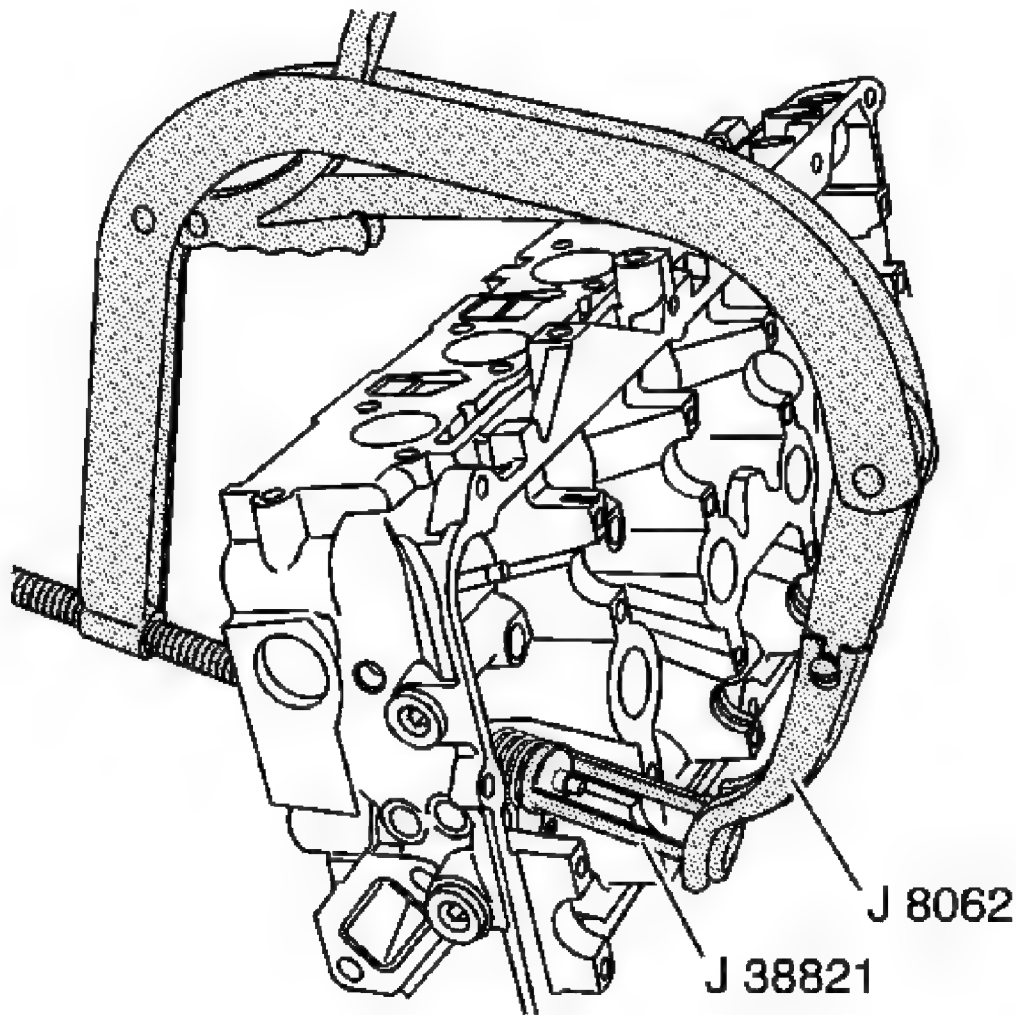


Fig. 39: View of J 8062 & J 38821
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the

valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

NOTE: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

2. Compress the valve spring with the **J 8062** and the **J 38821** . See **Special Tools** .

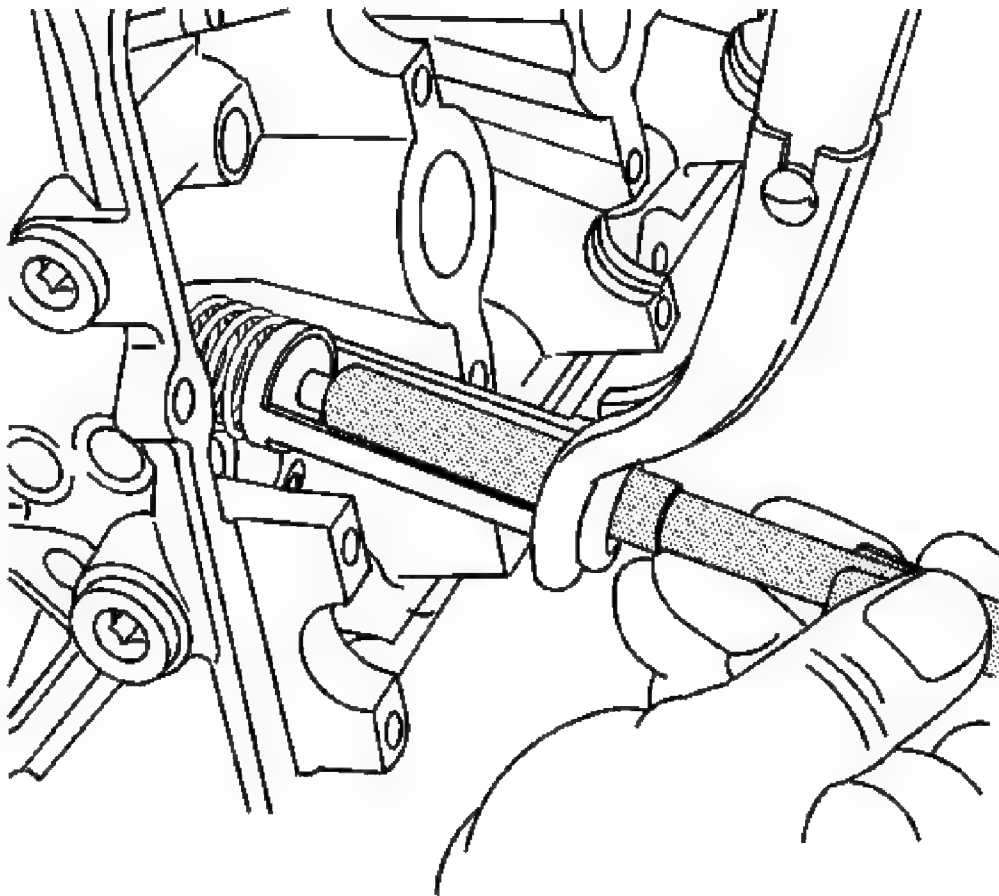


Fig. 40: View Of J 43059 & Valve Keepers
Courtesy of GENERAL MOTORS CORP.

3. Use the magnet end of the **J-43059-A** in order to remove the valve keepers. See **Special**

Tools .

4. Remove the **J 8062** and the **J 38821** . See **Special Tools** .

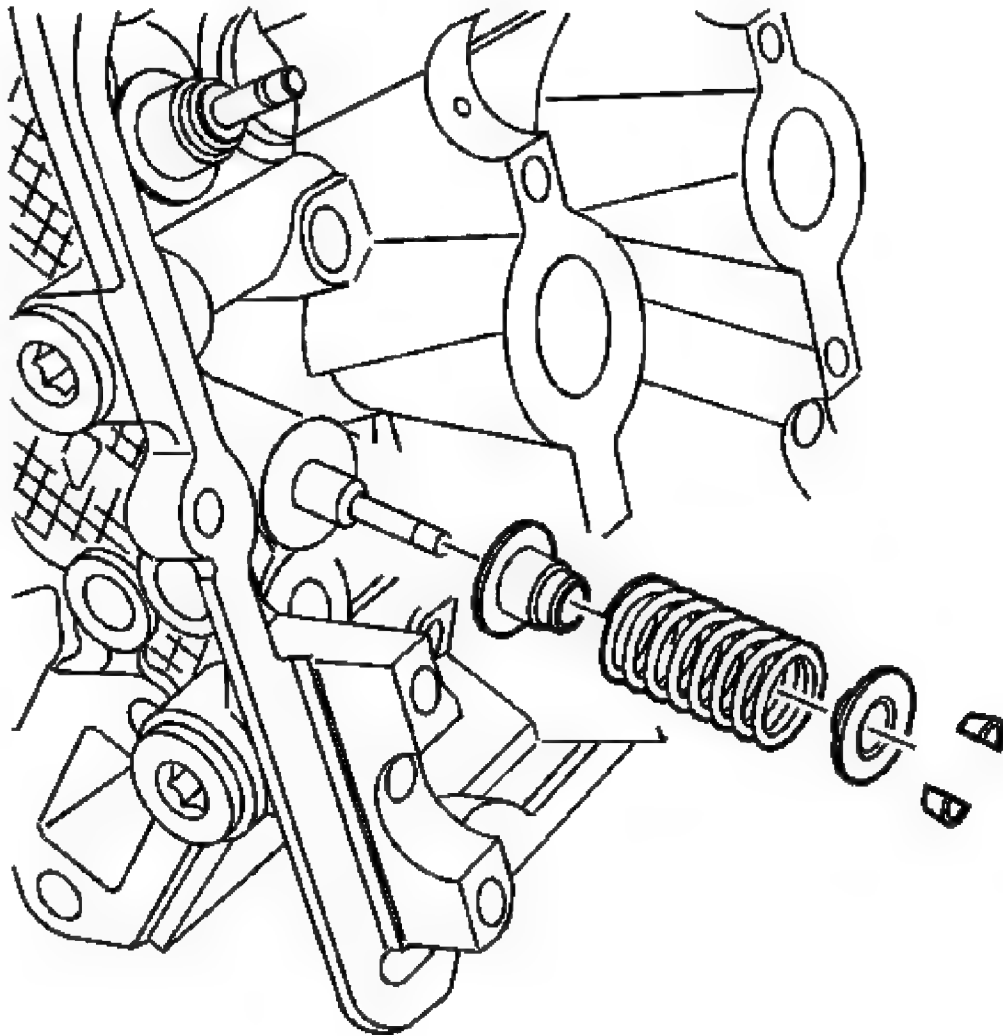


Fig. 41: Identifying Valve Spring Components
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve spring.

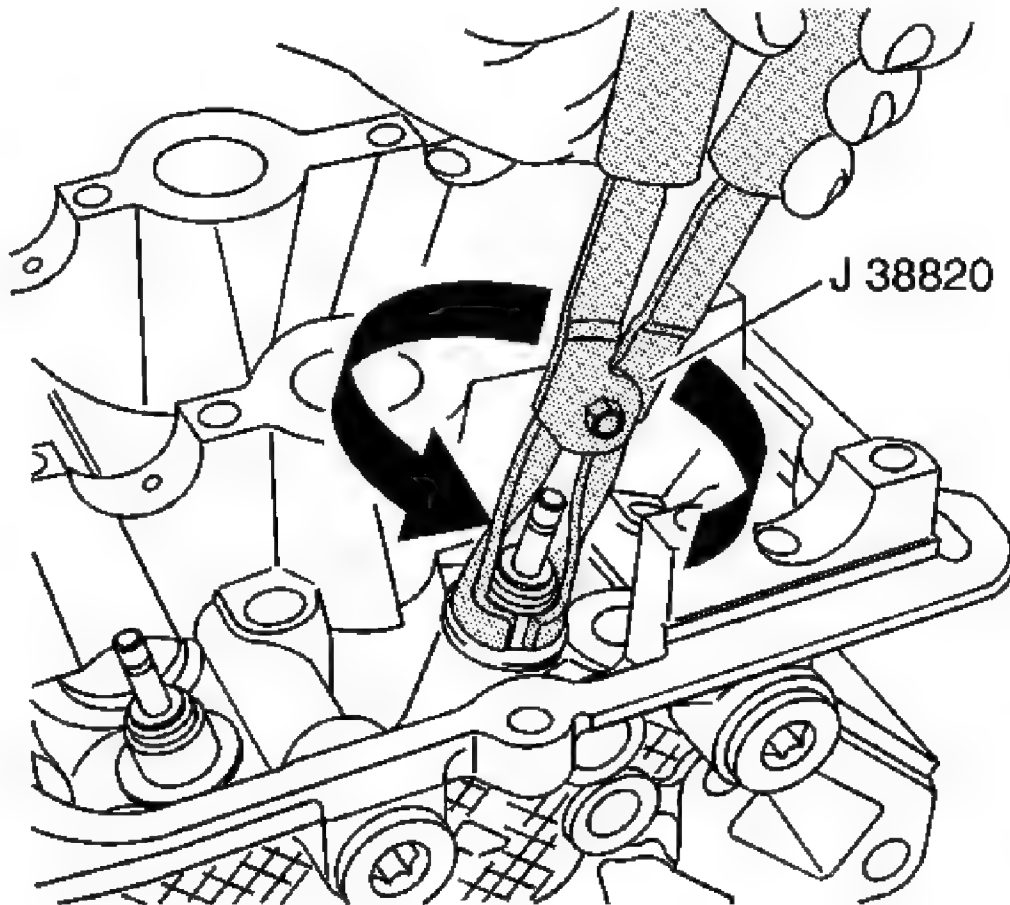


Fig. 42: Using J 38820 To Replace Valve Seal
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve seal with the **J 38820** . See **Special Tools** . Discard the valve seal, NEVER re-use the valve seal.
7. Remove the valve.
8. Repeat the procedure for the remaining valves.

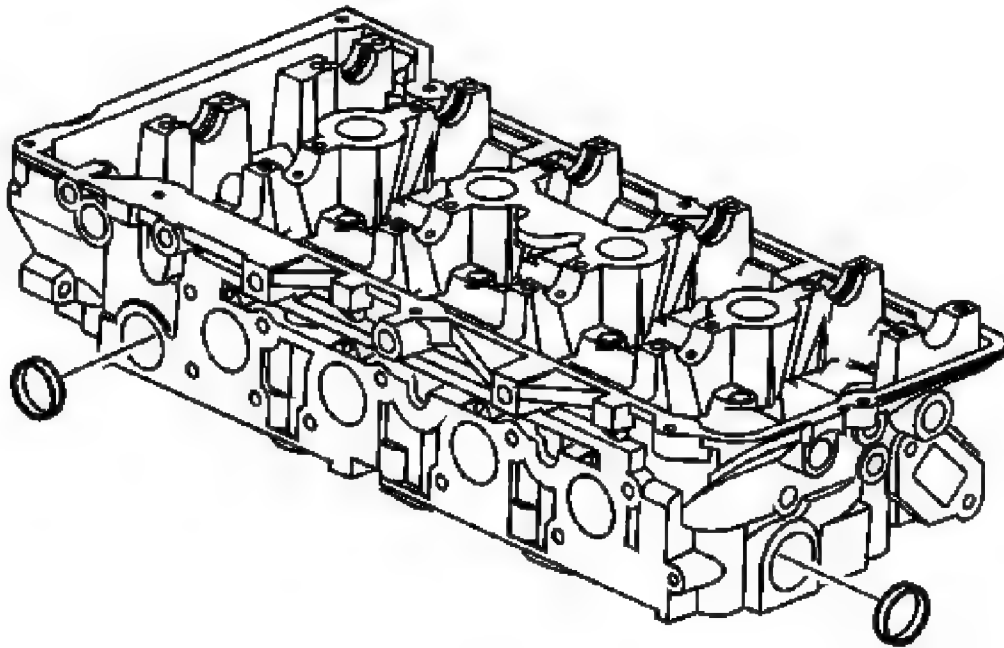


Fig. 43: Locating Left Cylinder Head Expansion Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

9. Remove the expansion coolant plugs from the left cylinder head.

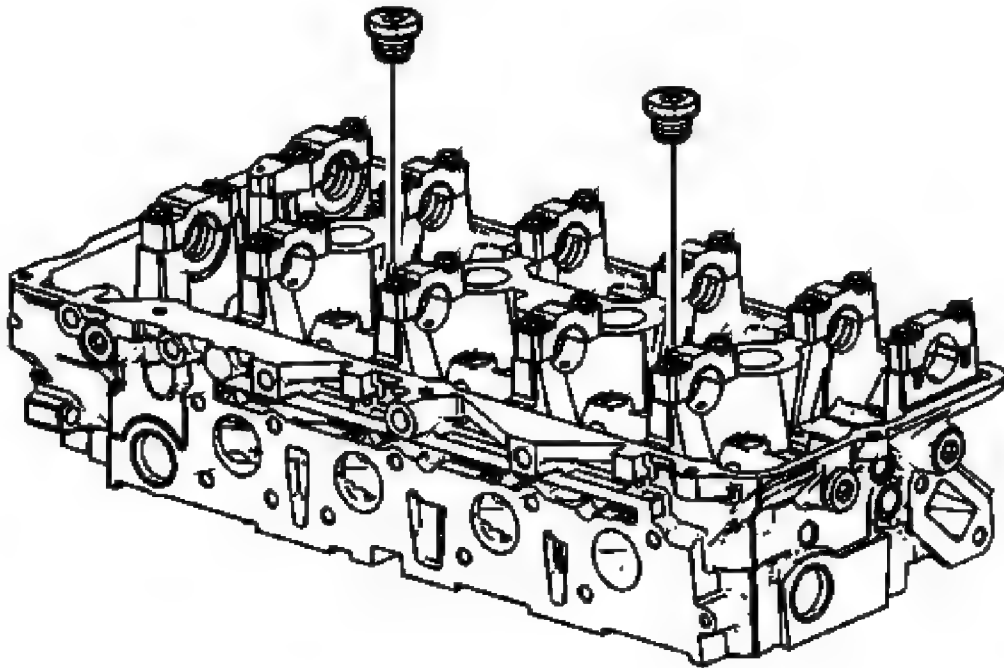


Fig. 44: View of Threaded Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the threaded coolant plugs from the left cylinder head.

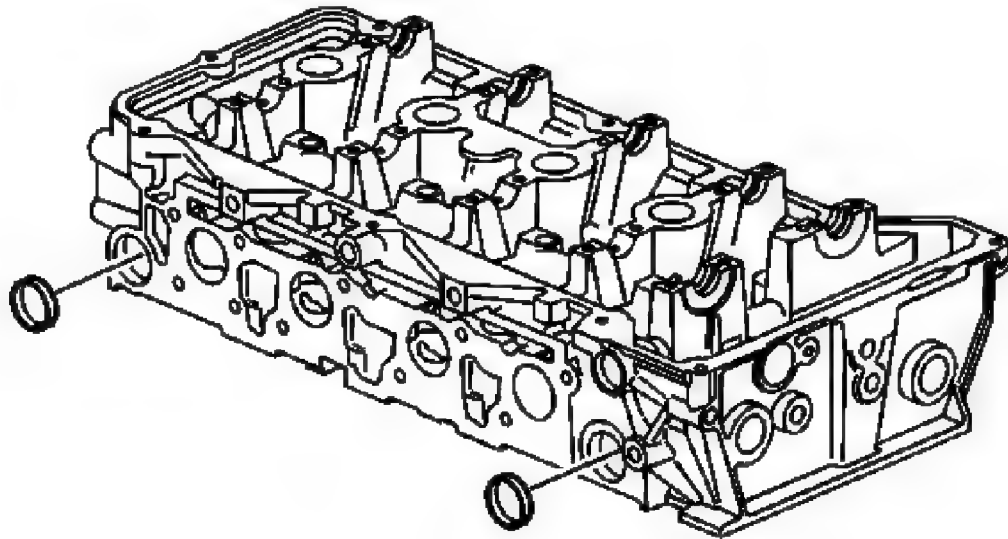


Fig. 45: View of Expansion Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

11. Remove the expansion coolant plugs from the right cylinder head.

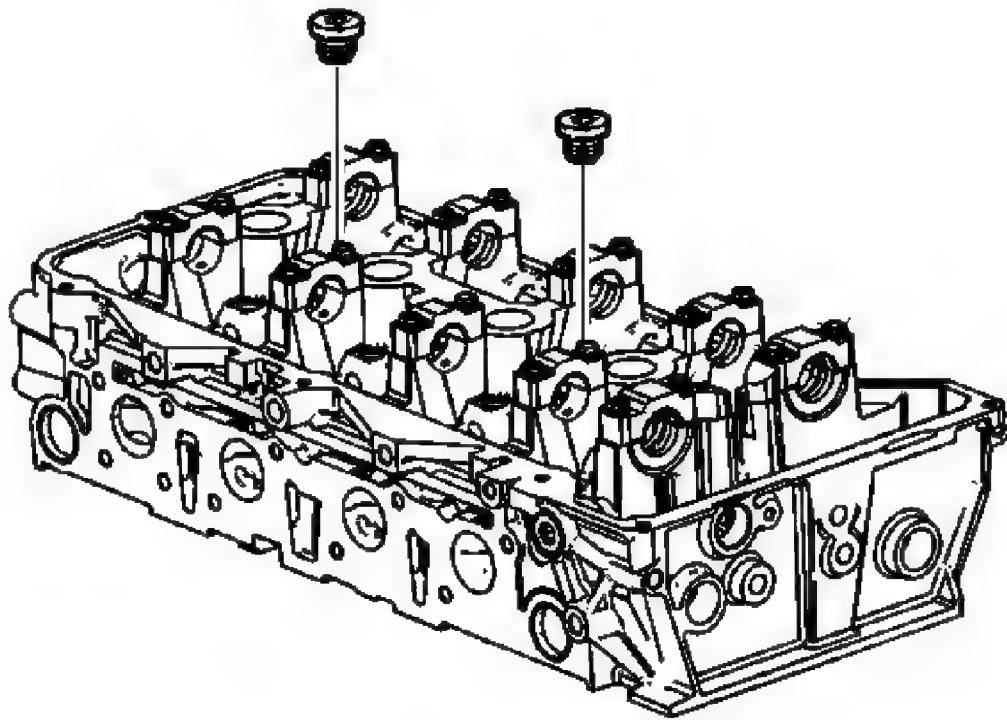


Fig. 46: View of Threaded Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

12. Remove the threaded coolant plugs from the right cylinder head.

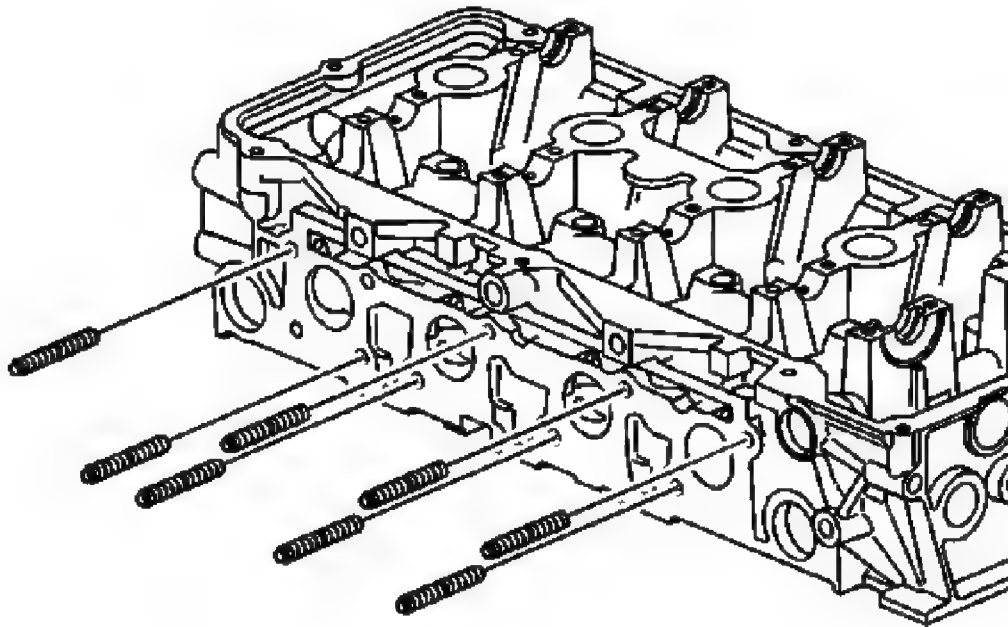


Fig. 47: View of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

13. Remove the exhaust manifold studs from the right cylinder head.

CYLINDER HEAD CLEANING AND INSPECTION

TOOLS REQUIRED

- **J 8001** Dial Indicator Set
- **J 8358** Carbon Removal Brush. See Special Tools .
- **J 28410** Gasket Remover. See Special Tools .

VISUAL INSPECTION PROCEDURE

1. Inspect the cylinder head for the following:
 - Cracks, damage or pitting in the combustion chambers.

IMPORTANT: DO NOT machine the camshaft bearing journals.

- Scoring of the camshaft bearings and/or the journals. If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head.

- Debris in the oil galleries. Continue to clean the galleries until all debris is removed.
 - Coolant leaks or damage to the deck face sealing surface. If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement.
 - Damage to any gasket surfaces
 - Damage to any threaded bolt holes
 - Burnt or eroded areas in the combustion chamber
 - Cracks in the exhaust ports and combustion chambers
 - External cracks in the water chamber
 - Restrictions in the intake or exhaust passages
 - Restrictions in the cooling system passages
 - Rusted, damaged or leaking core plugs
2. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.

CLEANING PROCEDURE

1. Clean all cylinder head surfaces with non-corrosive solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Blow out all the oil galleries using compressed air.
3. Remove any carbon deposits from the combustion chambers using the **J 8358**. See **Special Tools**.
4. Remove any gasket material with the **J 28410**. See **Special Tools**.
5. Clean any debris or build-up from the lifter pockets.
6. Inspect the cylinder head again for the items noted under Visual Inspection.

CYLINDER HEAD MEASUREMENT

NOTE: Refer to SPECIAL FASTENER NOTICE.

1. Measure the camshaft clearance specification using the following procedure:
1. Install the camshaft caps.
 2. Install the camshaft caps bolts.

Tighten: Tighten the camshaft bearing caps bolts to 5 N.m (44 lb in).

3. Measure the camshaft bearings using an inside micrometer.
 4. Inspect and measure the camshaft journal diameters. Refer to **Camshaft Cleaning and Inspection**.
 5. Subtract the camshaft journal diameter from the camshaft bearing diameter in order to obtain the running clearance.
 6. If the running clearance exceeds the specifications and the camshaft journals are within specification, replace the cylinder head. Refer to **Engine Mechanical Specifications**.
2. Measure the camshaft thrust specification using the following procedure:
1. Inspect each camshaft cap thrust surface for excessive scoring/wear.
 2. Inspect each camshaft. Refer to **Camshaft Cleaning and Inspection**.
 3. Install the intake and exhaust camshafts in the cylinder head.
 4. Install the camshaft caps.
 5. Install the camshaft caps bolts.

Tighten: Tighten the camshaft bearing caps bolts to 5 N.m (44 lb in).

6. Measure the camshaft thrust bearing clearance at the front camshaft bearing cap. Refer to **Engine Mechanical Specifications**.
7. If the camshaft thrust bearing clearance is not to specification repair or replace the cylinder head.

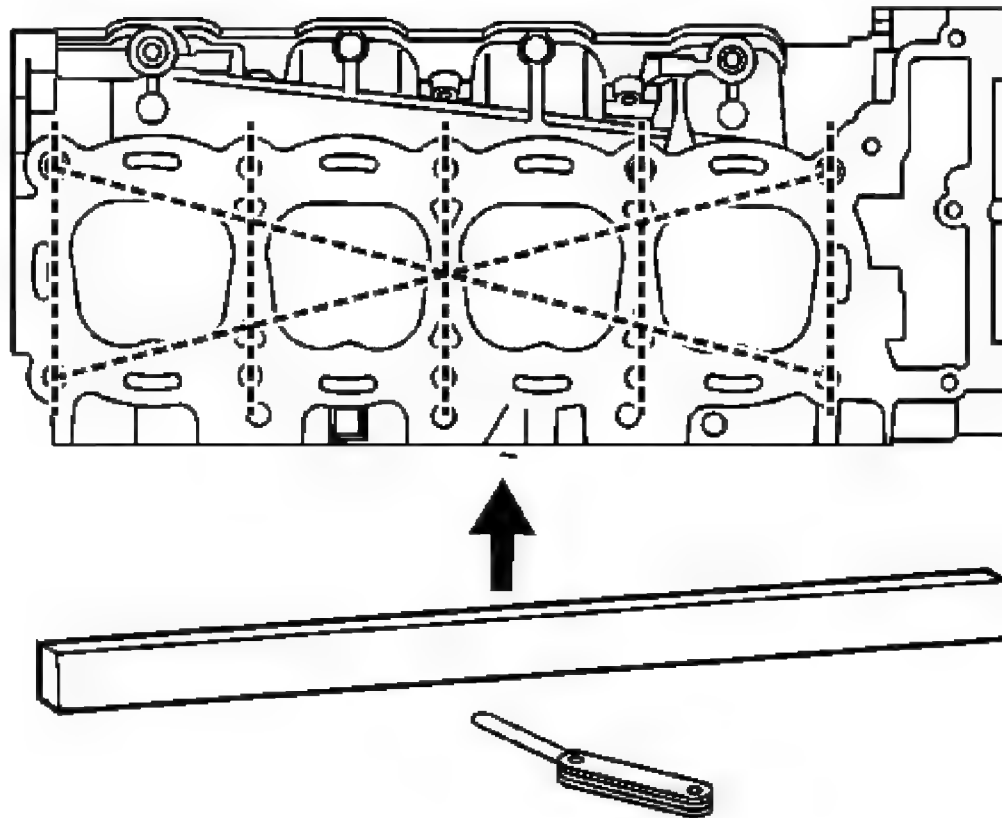


Fig. 48: Measuring Cylinder Head Flatness
Courtesy of GENERAL MOTORS CORP.

3. Measure the cylinder head flatness using the following procedure:
 1. Clean any remaining head gasket material from the cylinder head face.
 2. Place a straight-edge diagonally across the cylinder head face surface.
 3. Measure the clearance between the straight-edge and the cylinder head using a feeler gage at four points along the straight-edge.
 - If warpage is less than 0.05 mm (0.002 in), the cylinder head surface does not require resurfacing.
 - If warpage is between 0.05-0.20 mm (0.002-0.008 in), the cylinder head must be resurfaced.

VALVE GUIDE MEASUREMENT PROCEDURE

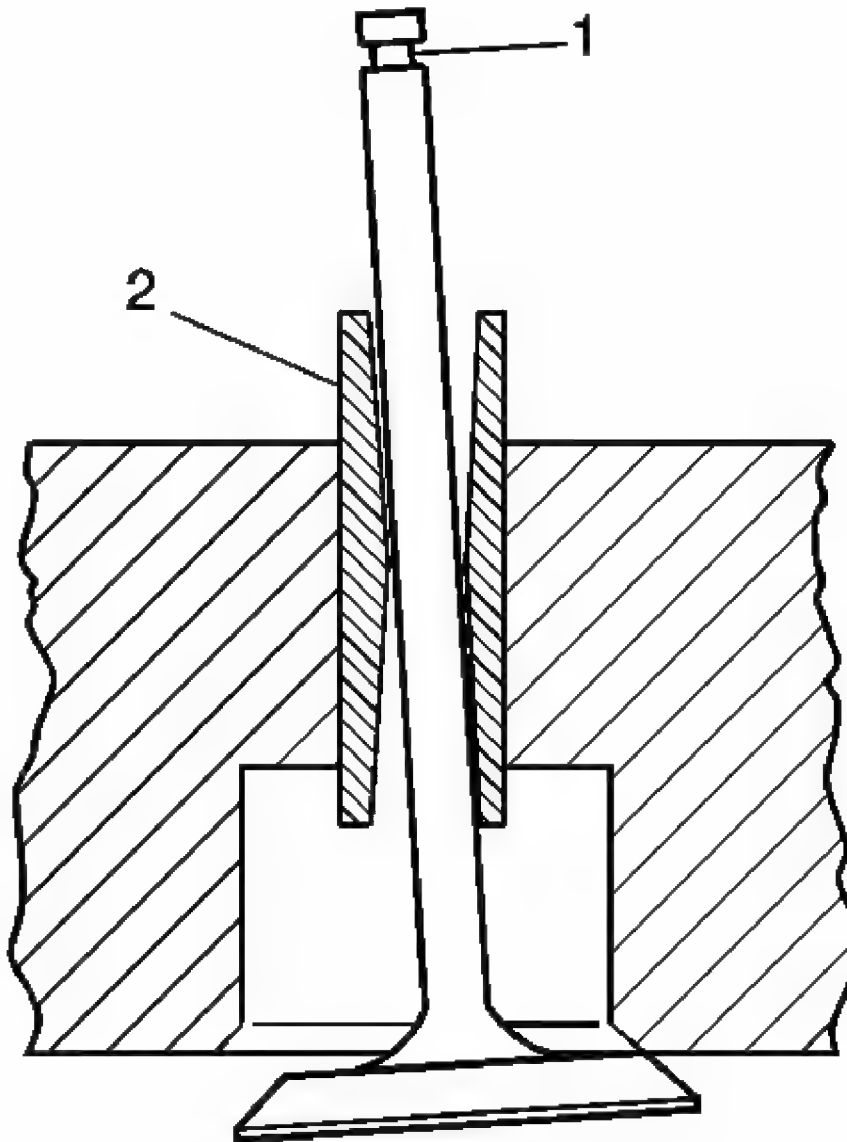


Fig. 49: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve stem (1)-to-guide (2) clearance as follows:
 - Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also case a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
 - Clamp the **J 8001** to the cylinder head at the camshaft cover rail.

- Locate the dial indicator so that the movement of the valve stem from side to side (crossways to the cylinder head) will cause a direct movement of the indicator stem.

The dial indicator stem must contact the side of the valve stem just above the valve guide.

- Drop the valve head about 1.6 mm (0.0064 in) off the valve seat.
 - Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading.
2. If the clearance for the intake valve is greater than 0.11 mm (0.0045 in) and a new standard diameter valve stem will not bring the clearance within specifications, the cylinder head must be replaced.
 3. If the clearance for the exhaust valve is greater than 0.12 mm (0.005 in) and a new standard diameter valve stem will not bring the clearance within specifications, the cylinder head must be replaced.
 4. Valve guide wear at the bottom 10 mm (0.39 in) of the valve guide is not significant to normal operation.

VALVE SPRING INSPECTION AND MEASUREMENT

TOOLS REQUIRED

J 22738-B Valve Spring Tester. See **Special Tools** .

INSPECTION PROCEDURE

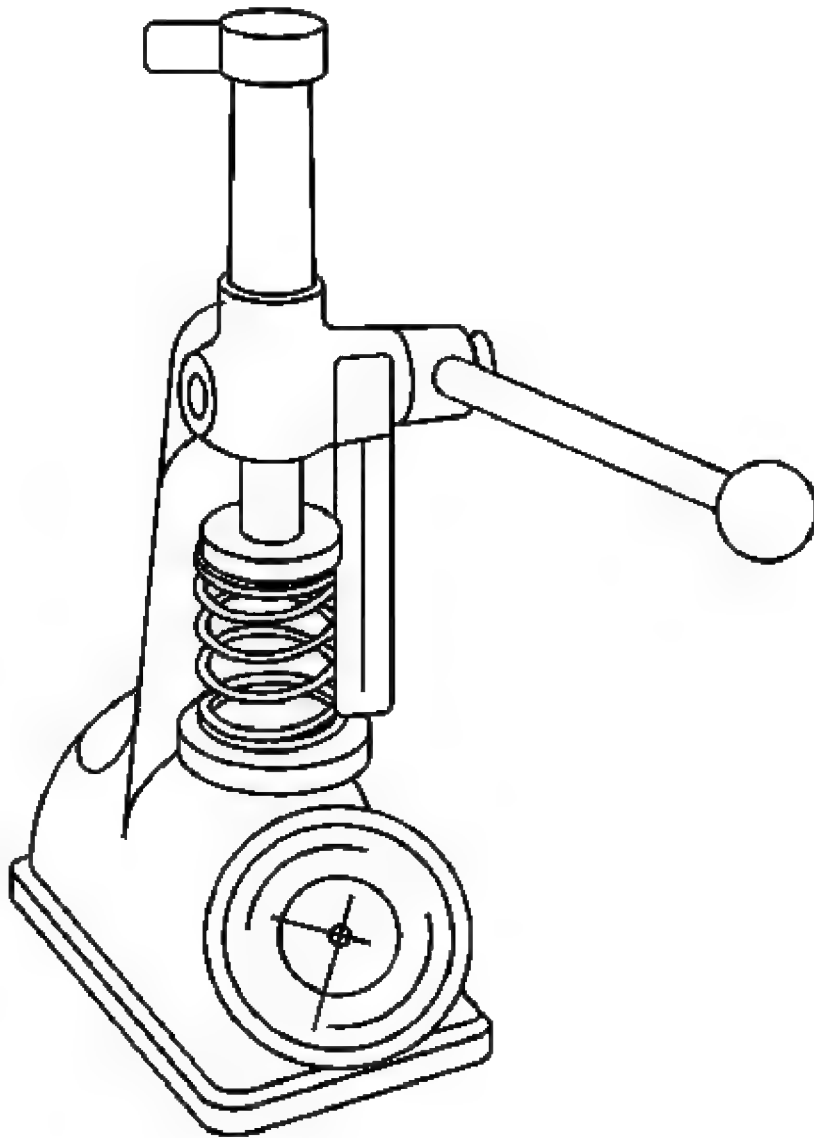


Fig. 50: Inspecting Valve Spring
Courtesy of GENERAL MOTORS CORP.

1. Place the valve spring in the **J 22738-B** . See **Special Tools** .
2. Compress the **J 22738-B** to the valve open, valve spring compressed, dimension listed in the **Engine Mechanical Specifications** .

NOTE: **DO NOT** use shims in order to increase valve spring load.
The use of shims will cause the valve spring to bottom out

before the camshaft lobe is at peak lift and engine damage could result.

3. If low valve spring load is found to be too low, replace the valve spring, DO NOT shim.

VALVE AND SEAT GRINDING

VALVE CLEANING PROCEDURE

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

VALVE VISUAL INSPECTION PROCEDURE

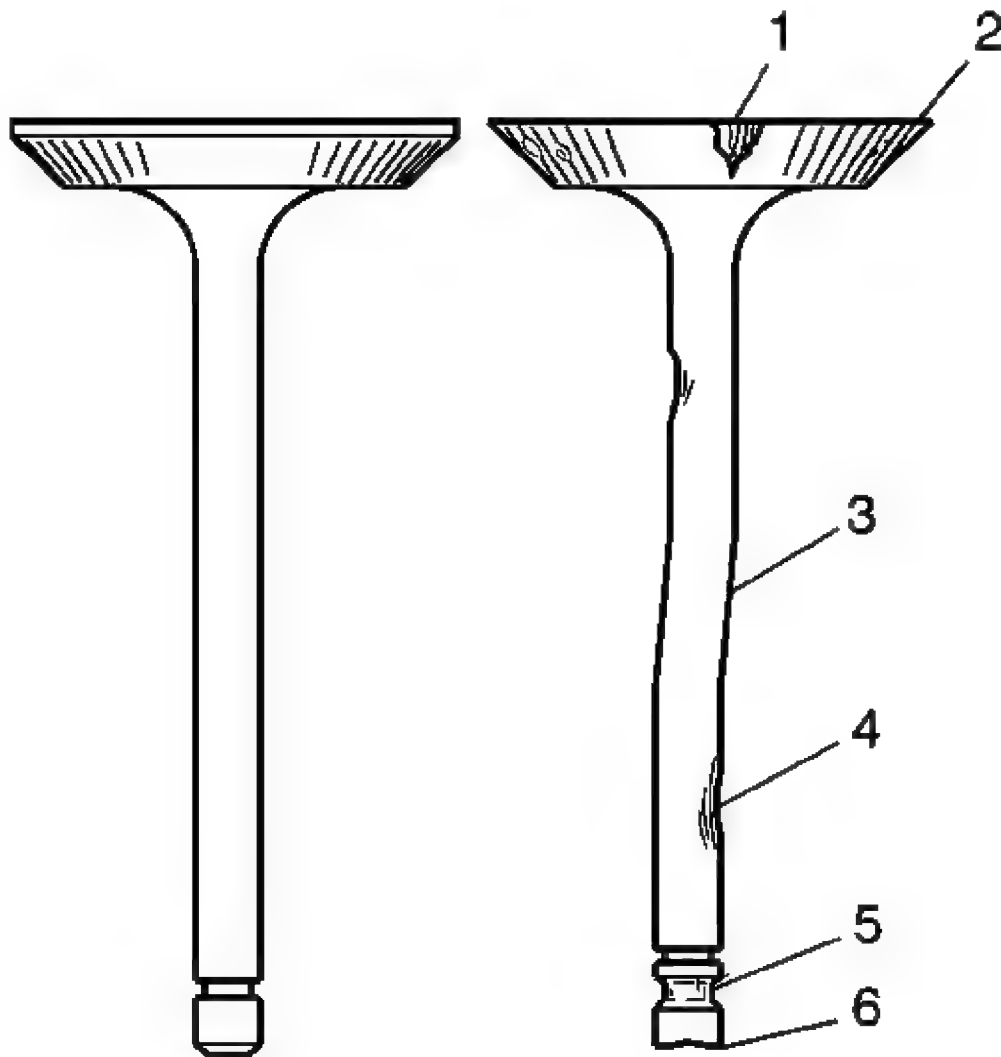


Fig. 51: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valve for damage from the head to tip for the following conditions:
 - Pitting in the valve seat area (1)
 - Lack of valve margin (2)
 - Bending in the valve stem (3)
 - Pitting or excessive wear in the stem (4)
 - Worn valve key grooves (5)
 - Worn valve tip (6)

2. Replace the valve if any of these conditions exist.

VALVE MEASUREMENT AND RECONDITIONING OVERVIEW

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

VALVE SEAT WIDTH MEASUREMENT PROCEDURE

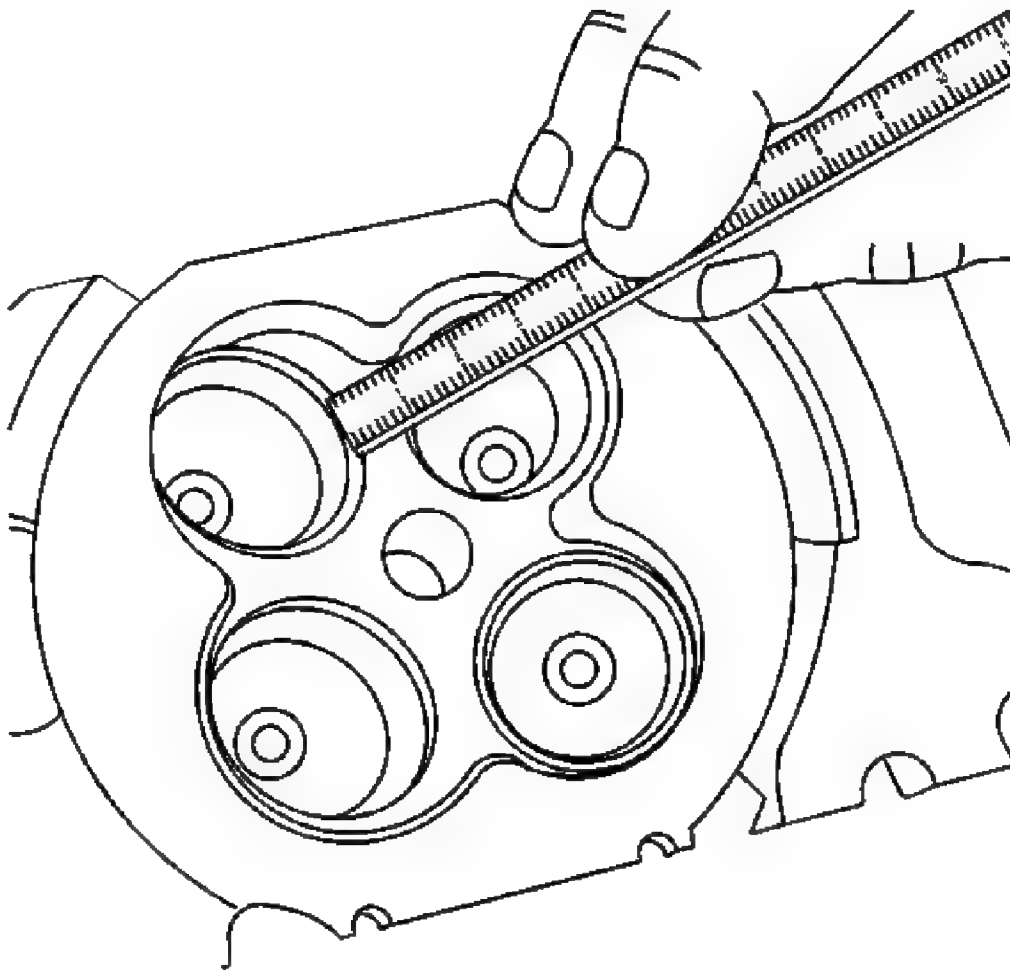


Fig. 52: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve seat width in the cylinder head using a proper scale.

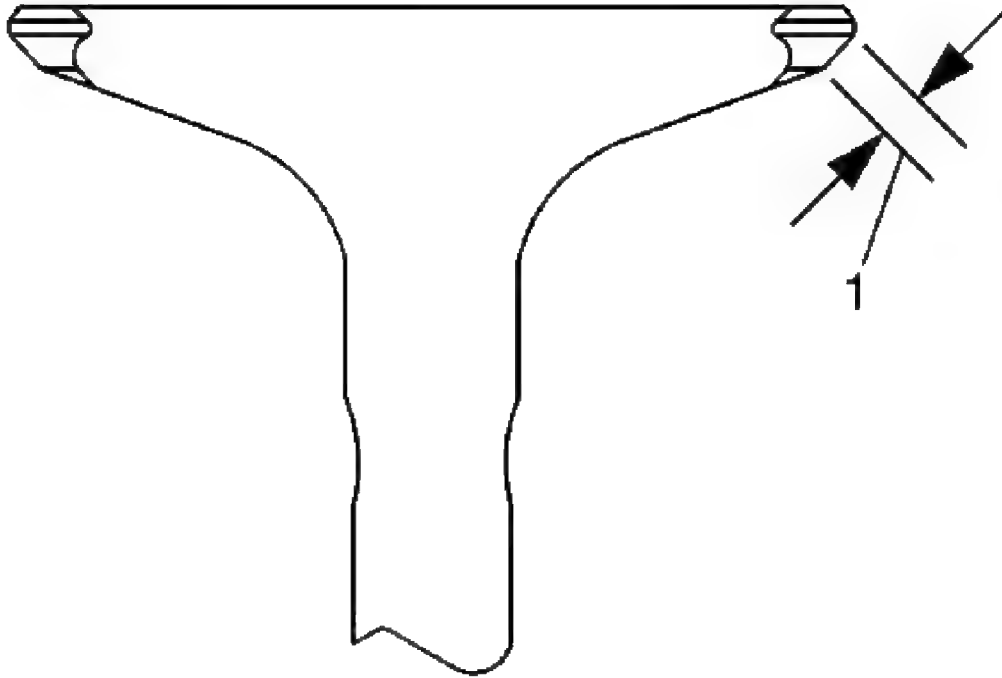


Fig. 53: Measuring Seat Width On Valve Face
Courtesy of GENERAL MOTORS CORP.

2. Measure the seat width on the valve face (1) using a proper scale.

IMPORTANT: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin, of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in **Engine Mechanical Specifications**.
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

VALVE SEAT ROUNDNESS MEASUREMENT PROCEDURE

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

NOTE: **The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.**

2. Compare your measurements with the specifications listed in **Engine Mechanical Specifications** .
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

VALVE MARGIN MEASUREMENT PROCEDURE

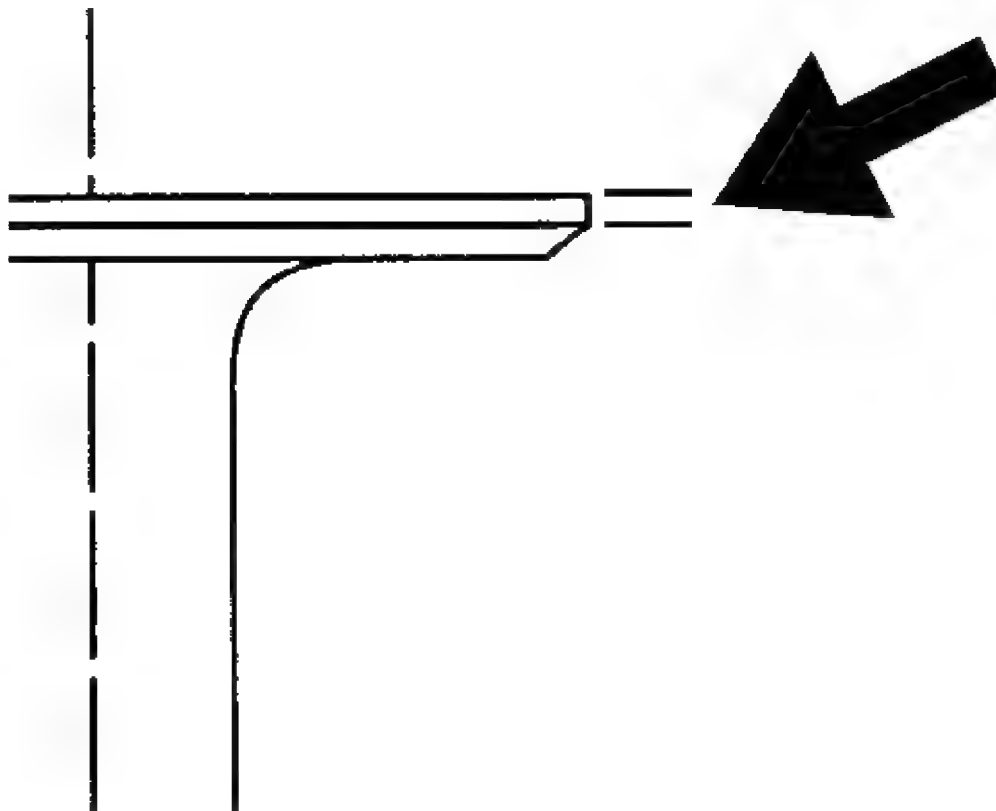


Fig. 54: View Of Valve Margin Measurement
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this article for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification and do not require refacing, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

VALVE-TO-SEAT CONCENTRICITY MEASUREMENT PROCEDURE

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.

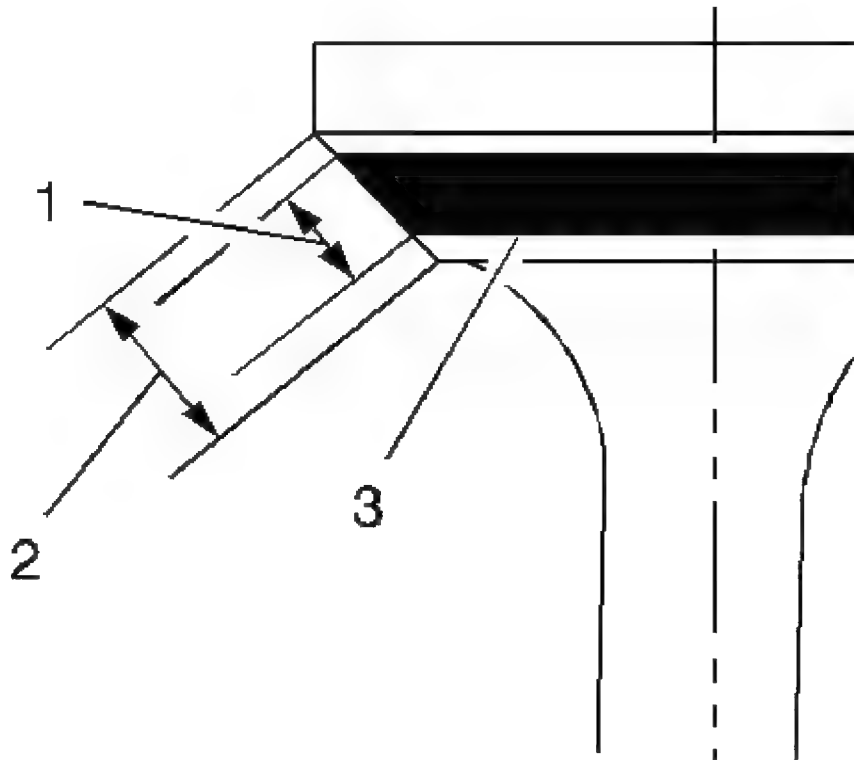


Fig. 55: View Of Valve Contact Face Measurements
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve face lightly with blue dye (3).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
 - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark will be made around the entire face (1).

IMPORTANT: The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

VALVE AND SEAT RECONDITIONING PROCEDURE

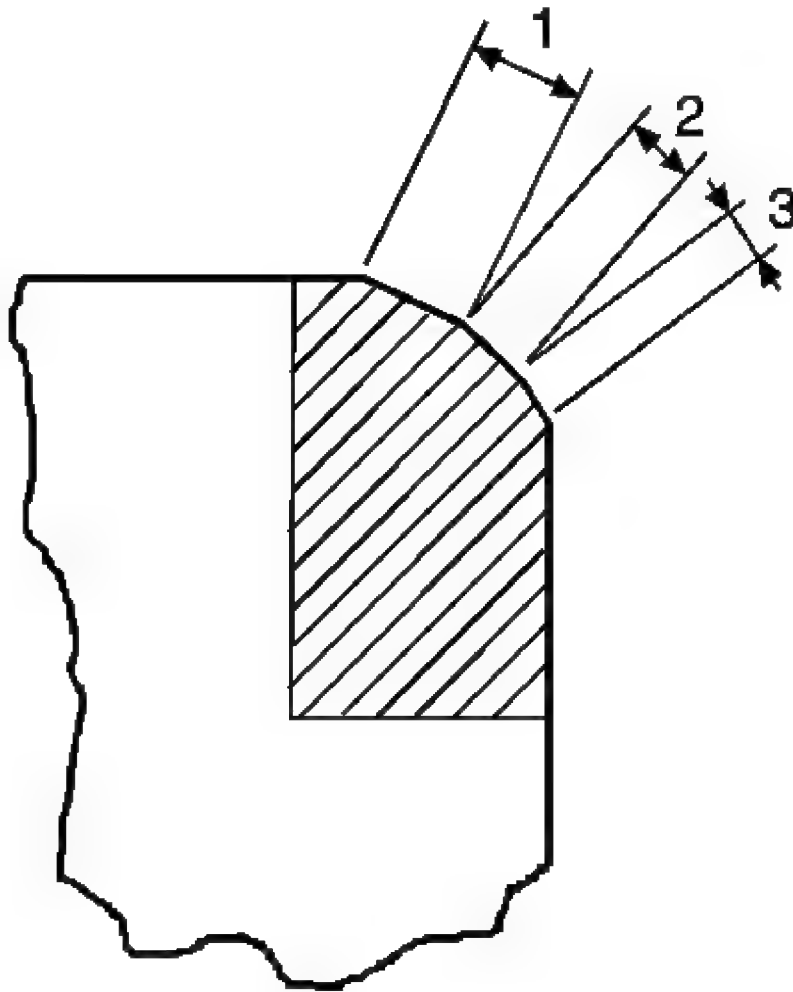


Fig. 56: View of Valve Seats

Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.
- It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications** .

2. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications** .
4. If the original valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications** . Measure the valve margin again after grinding using the Valve Margin Measurement Procedure. Replace the valve if the margin is out of specification. New valves do not require grinding.
5. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
6. Install the valve in the cylinder head.
 - If you are using refaced valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.

IMPORTANT: Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.

- If you are using new valves, do not lap the valves under any condition.
7. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
 8. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

VALVE STEM HEIGHT MEASUREMENT PROCEDURE

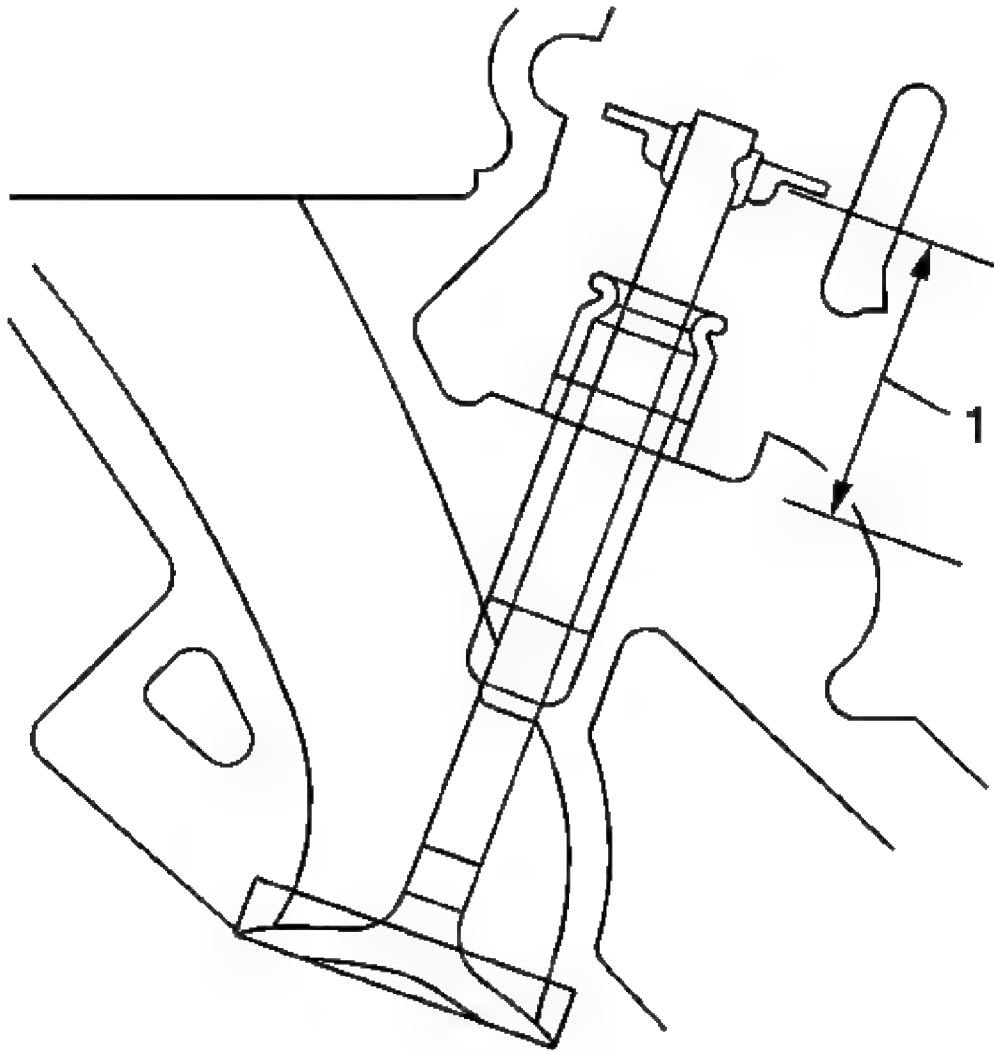


Fig. 57: Measuring Valve Stem Height
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve into the valve guide.
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.

5. Measure the distance (1) between the valve stem oil seal spring seat to the bottom of the valve spring retainer.
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

NOTE: **DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.**

NOTE: **DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.**

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CYLINDER HEAD ASSEMBLE

TOOLS REQUIRED

- **J 38820** Valve Stem Seal Installer. See **Special Tools** .
- **J 8062** Valve Spring Compressor. See **Special Tools** .
- **J 38821** Valve Spring Compressor Adapter. See **Special Tools** .
- **J-43059-A** Valve Retainer Remover/Installer. See **Special Tools** .

ASSEMBLY PROCEDURE

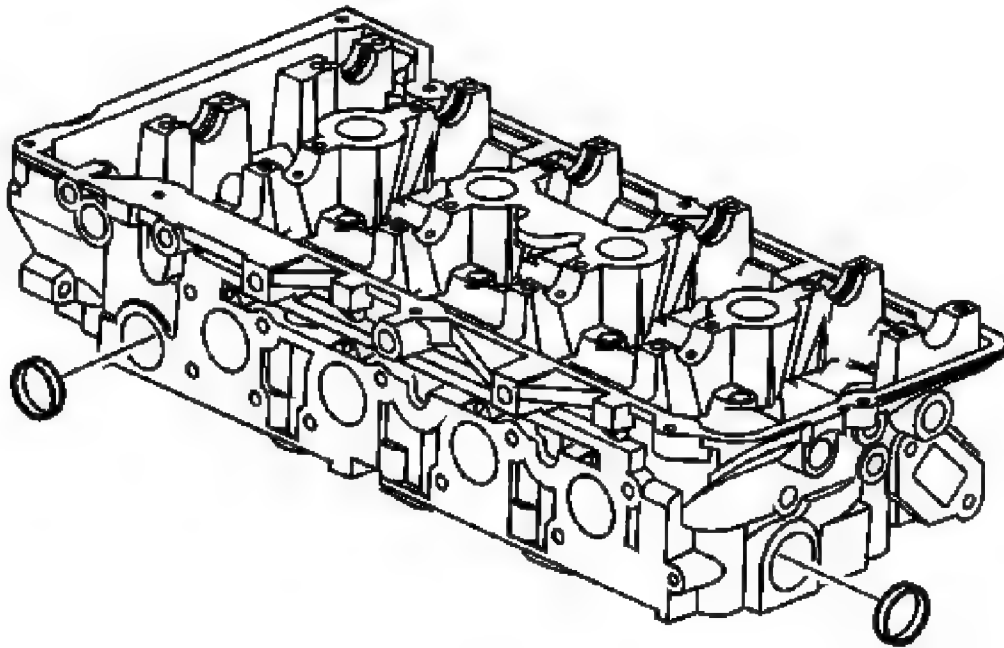


Fig. 58: View Of Expansion Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

1. Install the expansion coolant plugs into the left cylinder head.

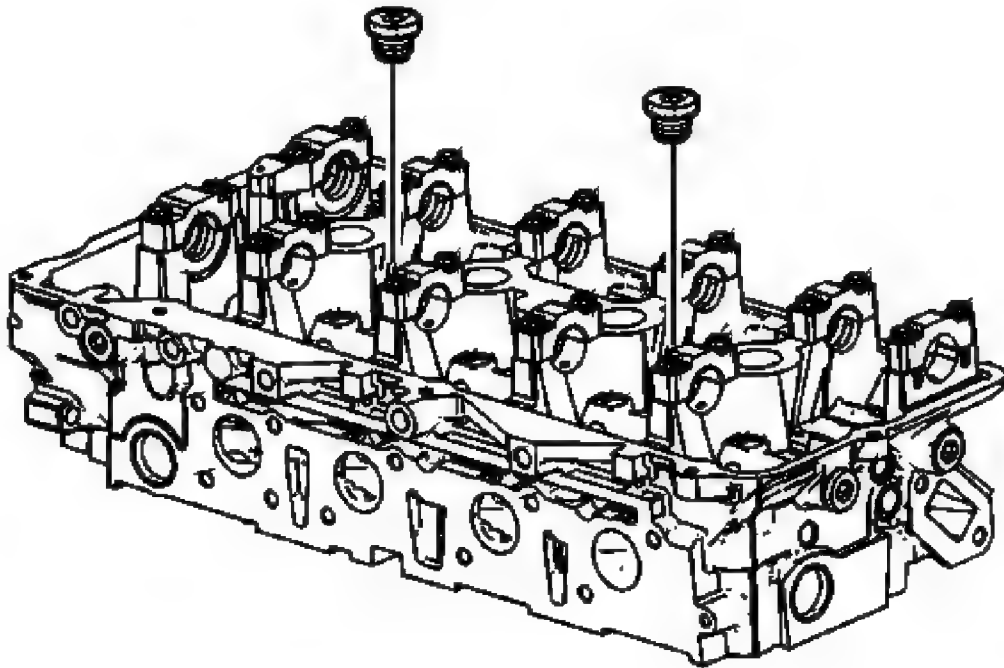


Fig. 59: View Of Threaded Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install the threaded coolant plugs into the left cylinder head.

Tighten: Tighten the threaded coolant plugs to 80 N.m (59 lb ft).

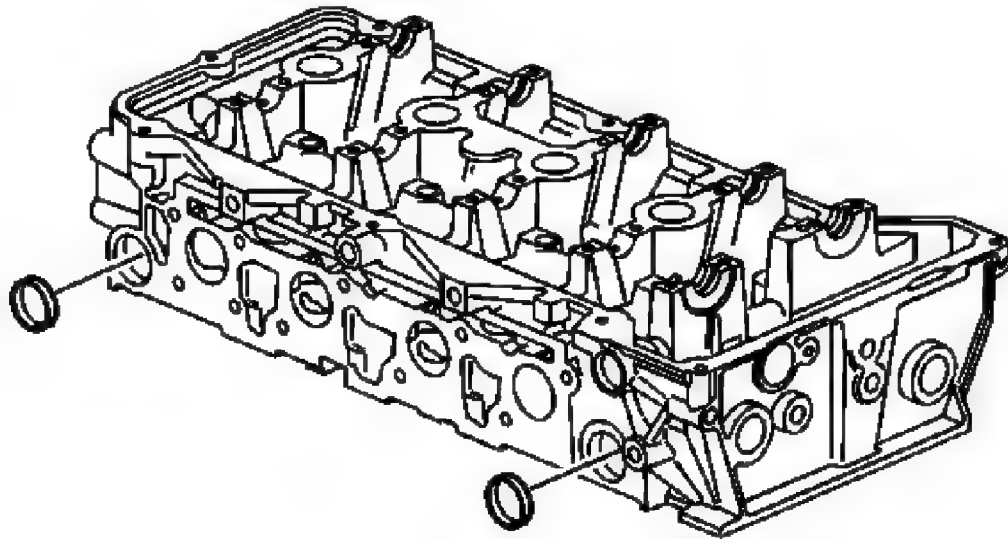


Fig. 60: View Of Expansion Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

3. Install the expansion coolant plugs into the right cylinder head.

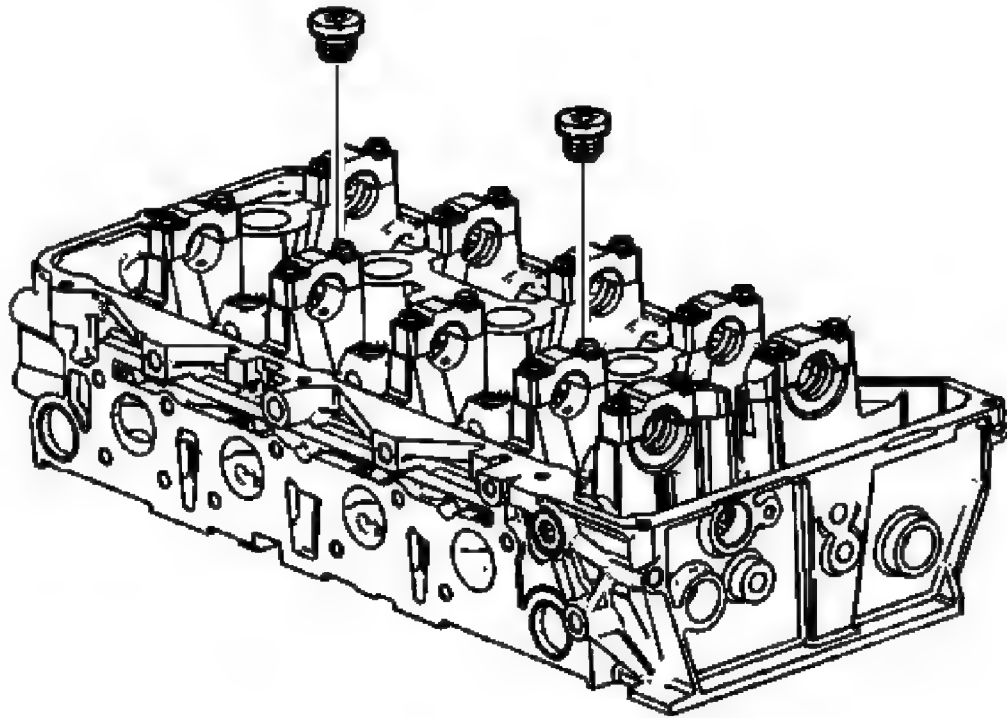


Fig. 61: View Of Threaded Coolant Plugs
Courtesy of GENERAL MOTORS CORP.

4. Install the threaded coolant plugs into the right cylinder head.

Tighten: Tighten the threaded coolant plugs to 80 N.m (59 lb ft).

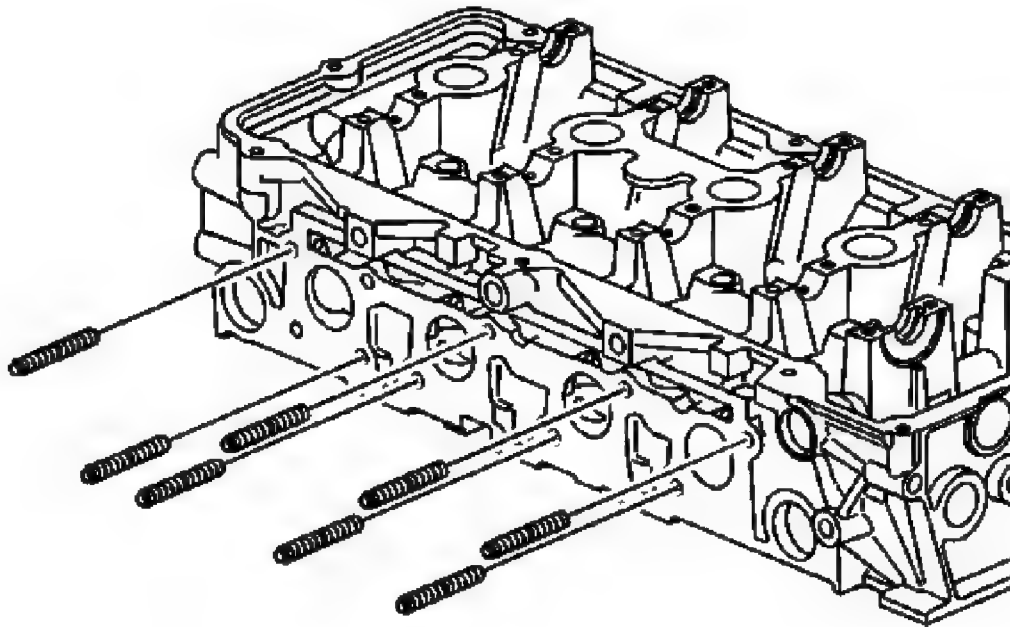


Fig. 62: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust manifold studs into the right cylinder head.

Tighten: Tighten the exhaust manifold studs to 6 N.m (53 lb in).

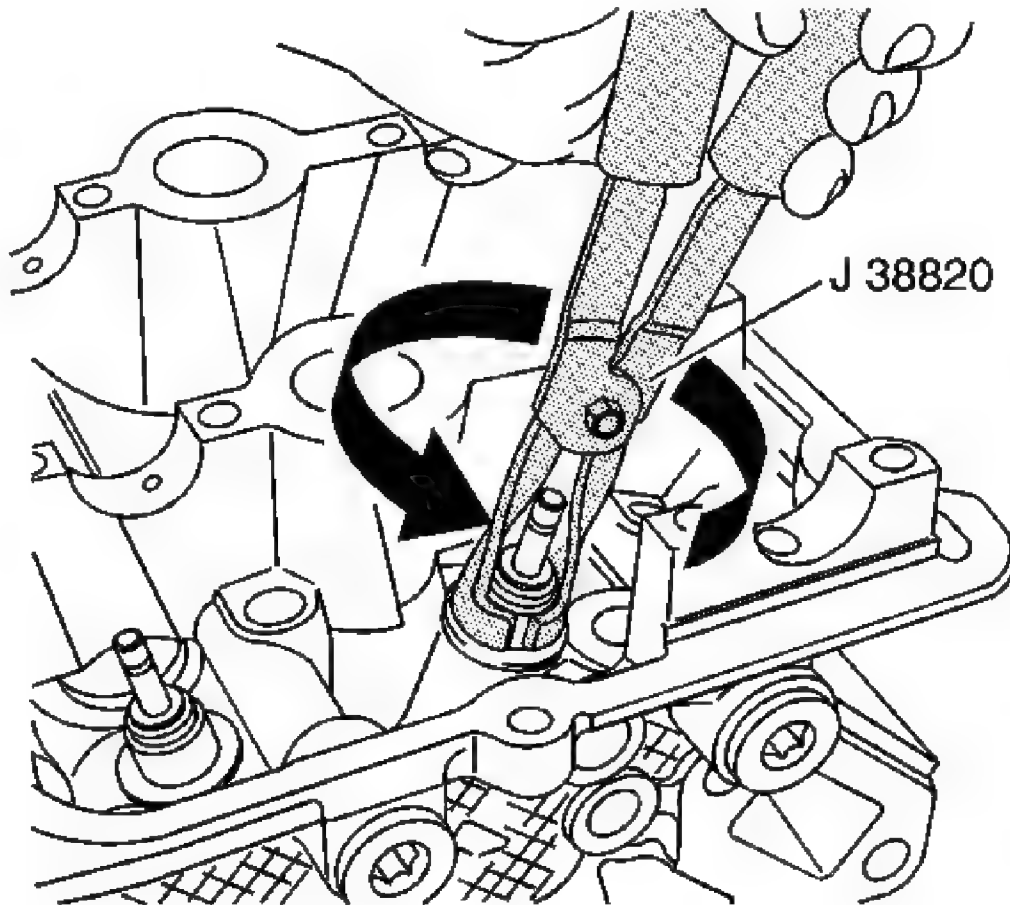


Fig. 63: Using J 38820 To Replace Valve Seal
Courtesy of GENERAL MOTORS CORP.

6. Lubricate the valve stem with clean engine oil.
7. Insert the valve into the valve guide until it bottoms on the valve seat.
8. Lubricate the new valve seal with engine oil.
9. Using the **J 38820** , install the new valve seal using the following procedure: See **Special Tools** .
 1. Place the valve lifter bore protector into the lifter bore.
 2. Mount the new valve seal in the **J 38820** . See **Special Tools** .
 3. Push and twist the new valve seal into position on the valve guide until the seal positively locks on the guide.

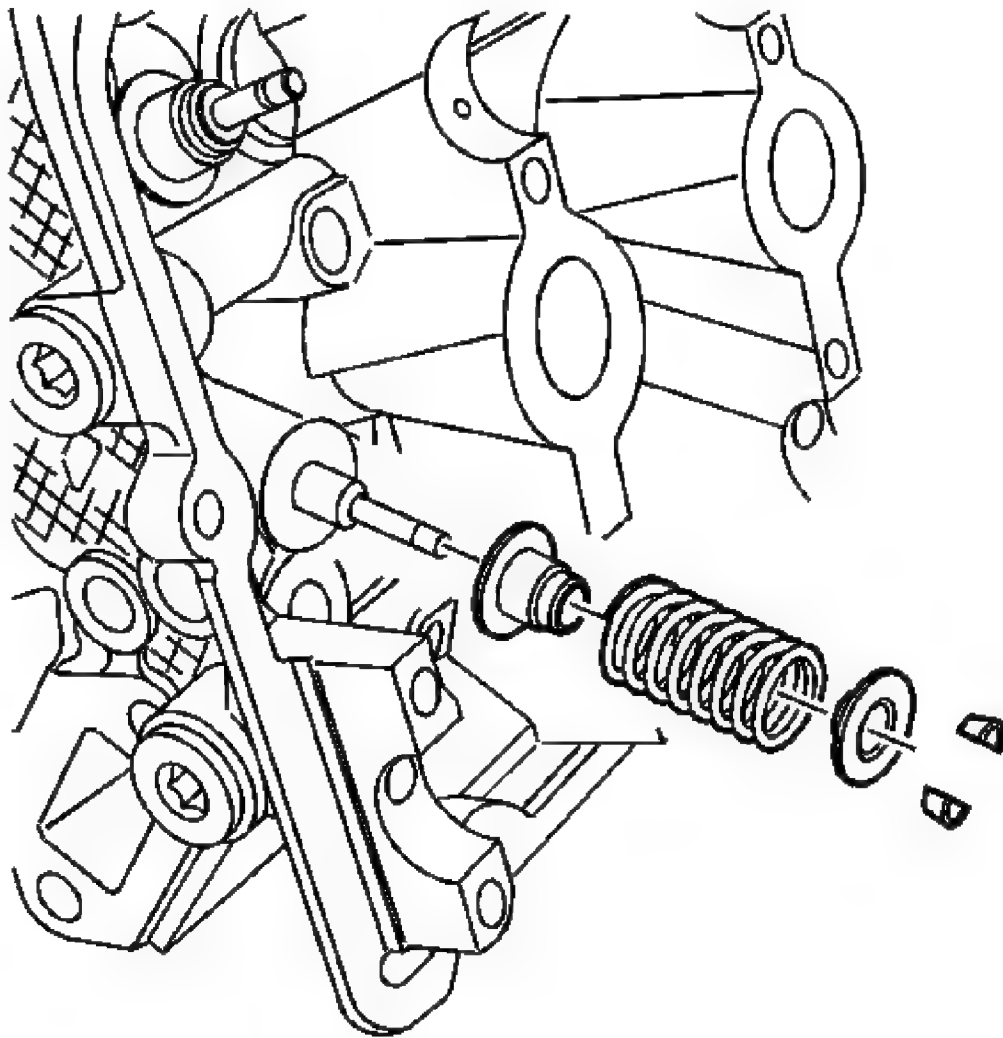


Fig. 64: Identifying Valve Spring Components
Courtesy of GENERAL MOTORS CORP.

10. Position the valve spring on the spring seat.

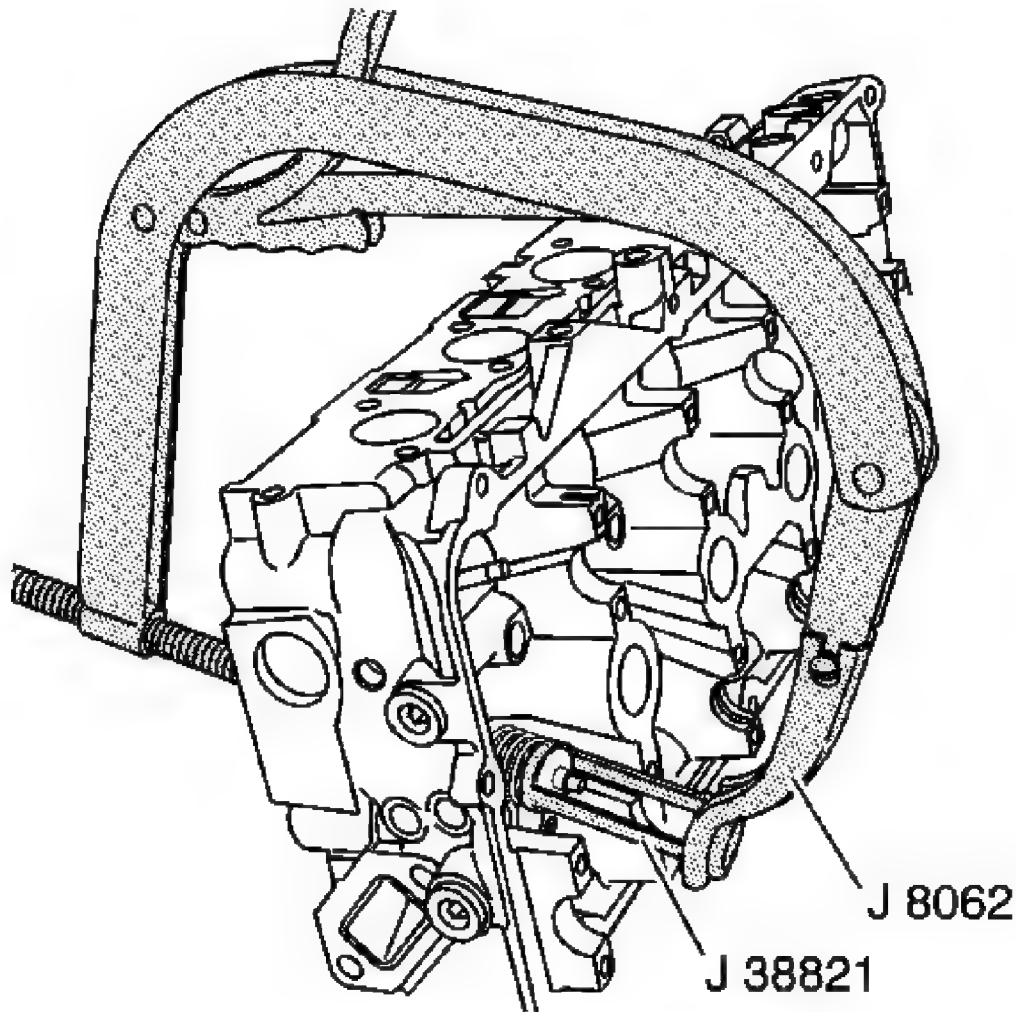


Fig. 65: View Of J 8062 & J 38821
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

NOTE: Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

11. Compress the valve spring using the **J 8062** and the **J 38821** . See Special Tools .

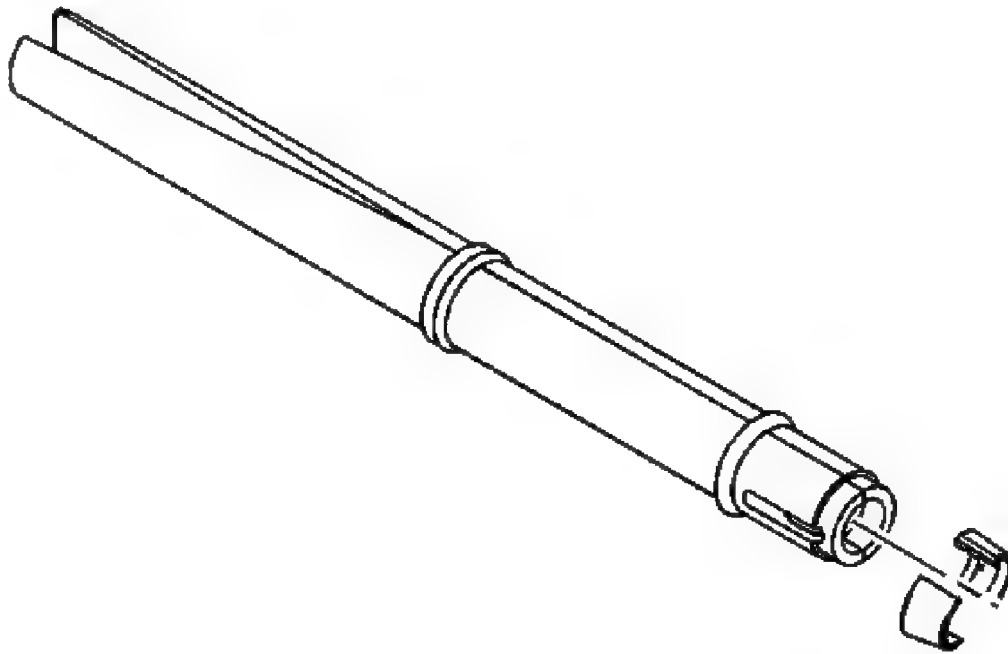


Fig. 66: Installing Valve Keepers With EN 46117
Courtesy of GENERAL MOTORS CORP.

12. With the spring compressed, install the valve keepers into the **J-43059-A** . See Special Tools .

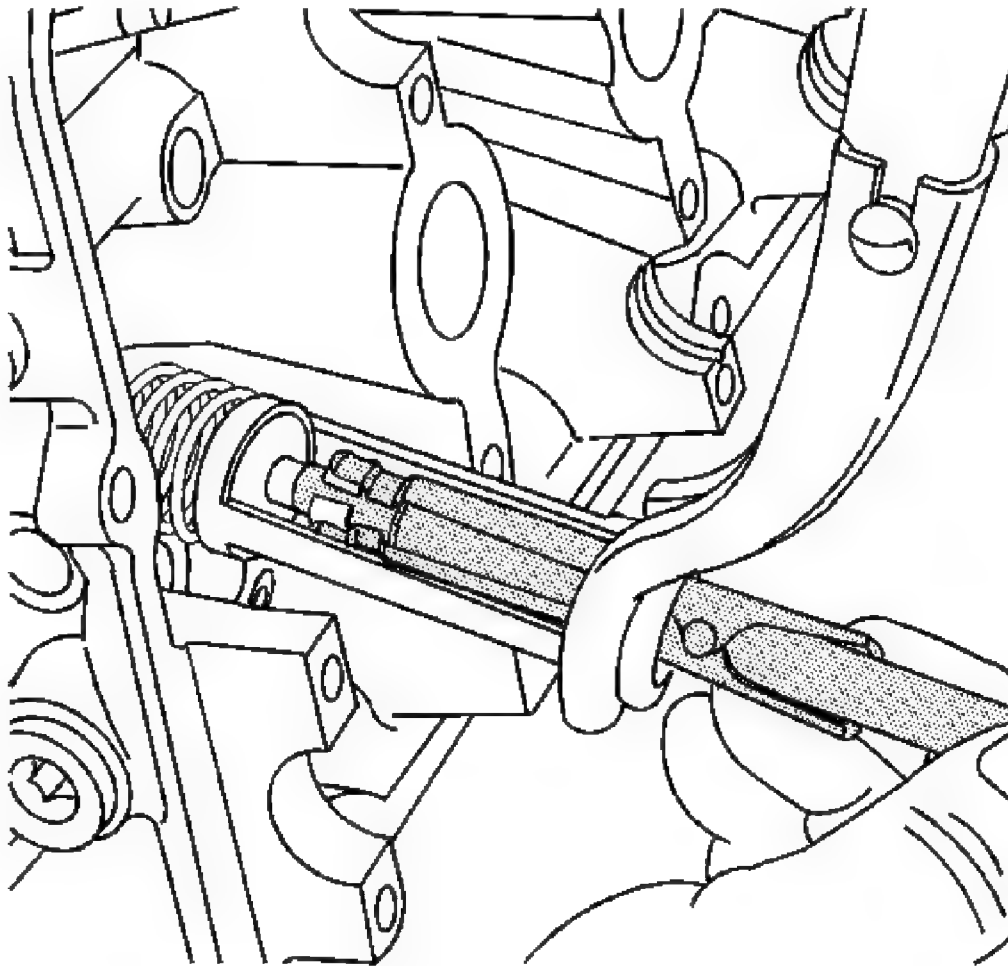


Fig. 67: View Of Valve Keepers & J 43059
Courtesy of GENERAL MOTORS CORP.

13. Place the keepers into position by pushing the tool downward.
14. Release the tension on the spring compressor and remove the **J 38821** . See **Special Tools** .
15. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.
16. Repeat this procedure for the remaining valves.

CAMSHAFT CLEANING AND INSPECTION

TOOLS REQUIRED

J 7872 Magnetic Base Dial Indicator

CLEANING PROCEDURE

1. Clean the camshaft in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the camshaft with compressed air.
3. Cover the camshafts with a clean oil soaked towel in order to prevent corrosion.

VISUAL INSPECTION PROCEDURE

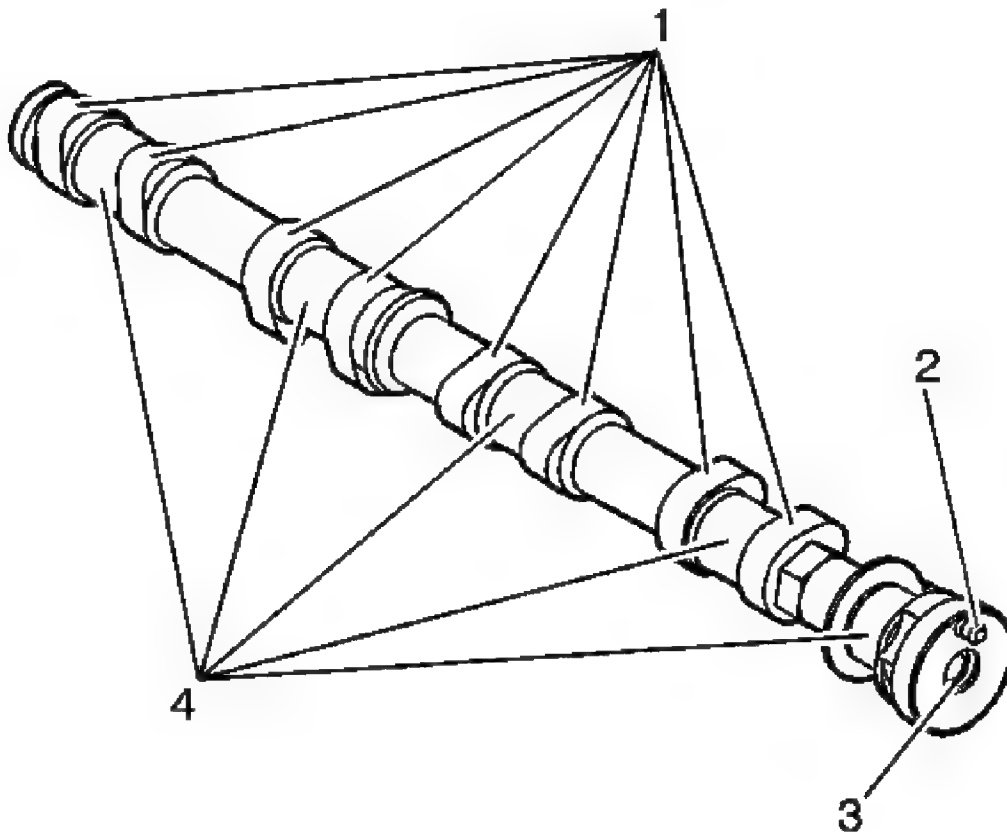


Fig. 68: Inspecting Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft sprocket locating pin (2) for damage or wear.

2. Inspect the threads (3) for the camshaft sprocket bolt.
3. Inspect the camshaft lobes (1) and journals (4) for the following conditions:
 - Excessive scoring or pitting
 - Discoloration from overheating
 - Deformation from excessive wear, especially the camshaft lobes

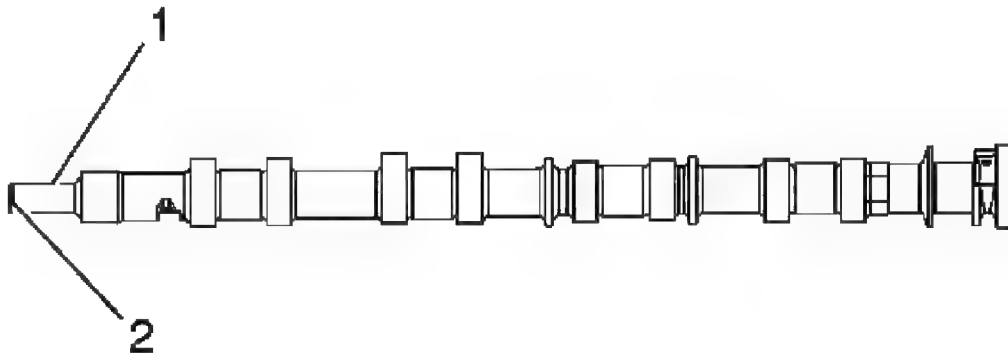


Fig. 69: Identifying Sealing Surface & Threads
Courtesy of GENERAL MOTORS CORP.

4. Inspect the left intake camshaft for the following additional conditions:
 - Excessive wear on the sealing surface (1) for the camshaft seal
 - Damage to the threads (2) for the water pump drive belt pulley bolt
5. If any of the above conditions exist on the camshaft, replace the camshaft.

CAMSHAFT MEASUREMENT PROCEDURE

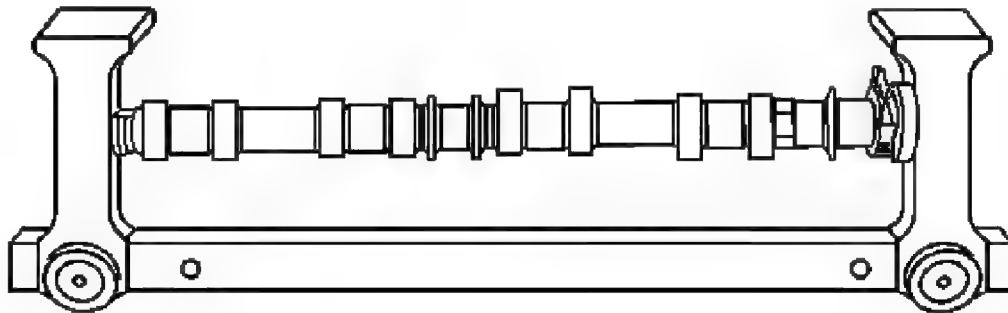


Fig. 70: Supporting Camshaft
Courtesy of GENERAL MOTORS CORP.

1. With the camshaft in a suitable fixture, measure the camshaft for wear.

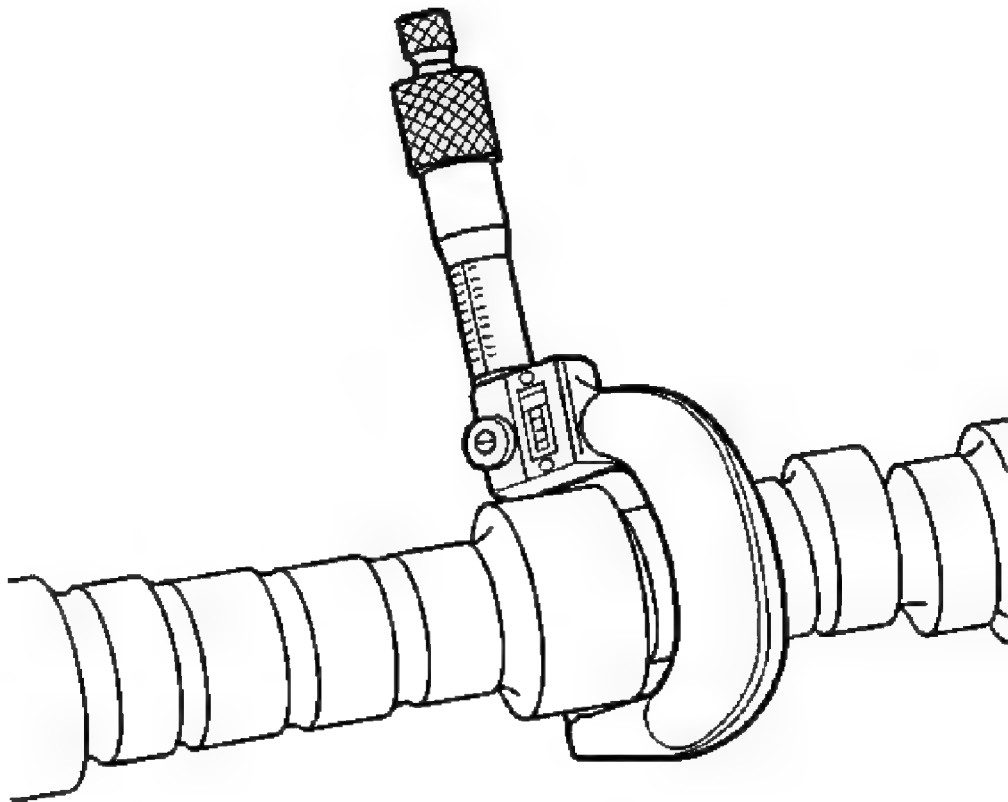


Fig. 71: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer.
 - If the diameter is smaller than 26.948 mm (1.061 in), replace the camshaft.
 - If the out-of-round exceeds 0.022 mm (0.0009 in), replace the camshaft.

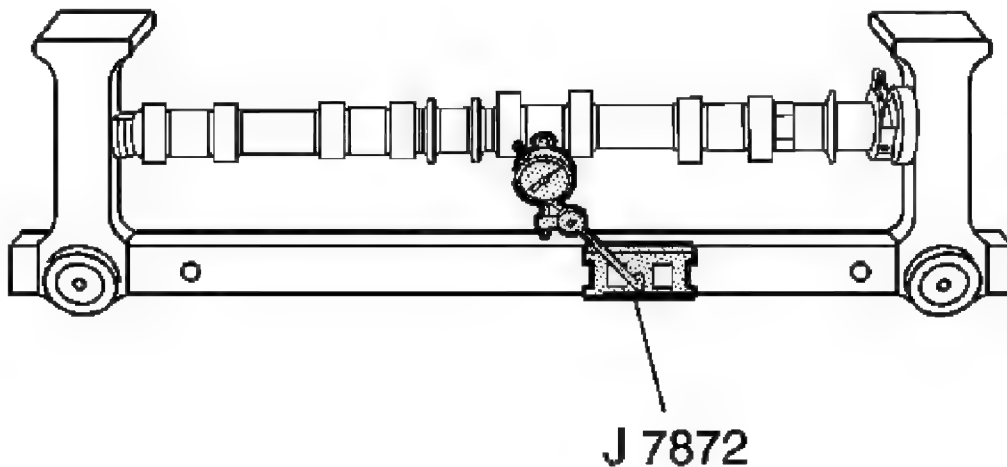


Fig. 72: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

3. Measure the camshaft runout using **J 7872** . Refer to **Engine Mechanical Specifications** .

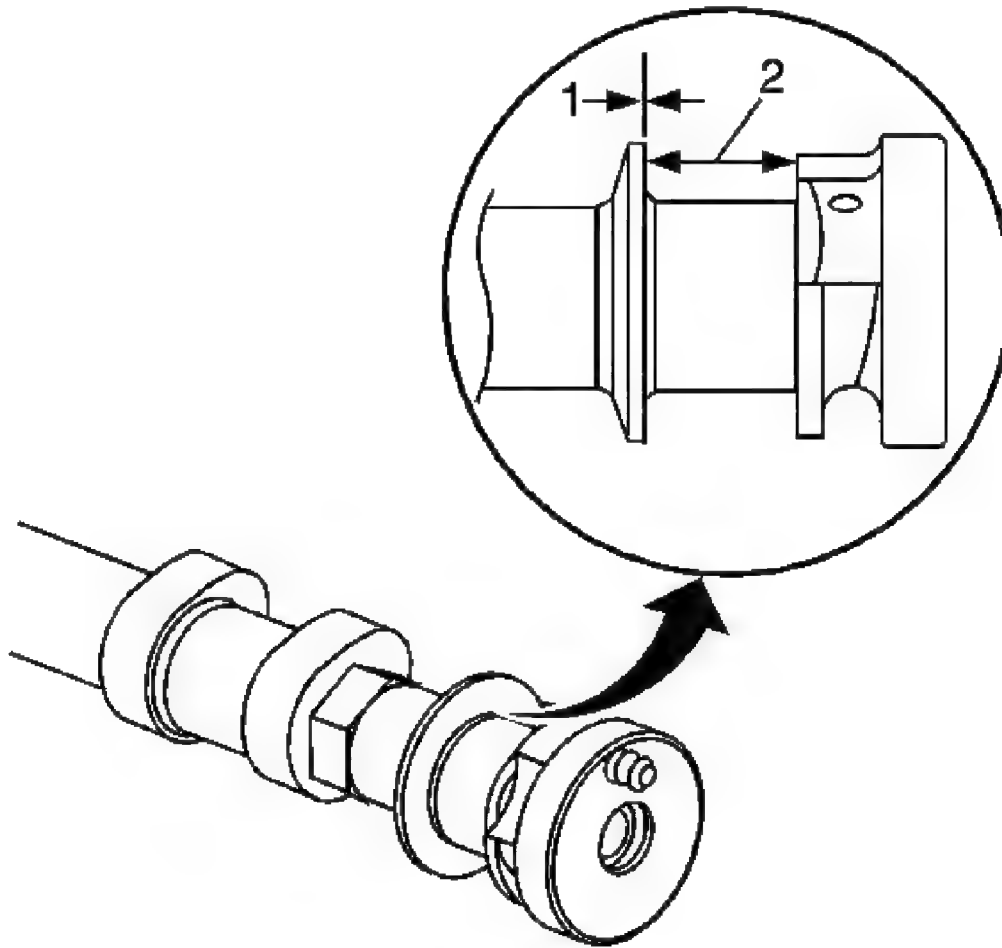


Fig. 73: Measuring Camshaft Thrust Wall Width & Surface Runout
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications** .
5. Measure the camshaft thrust wall surface (2) for runout using **J 7872** . Refer to **Engine Mechanical Specifications** .
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

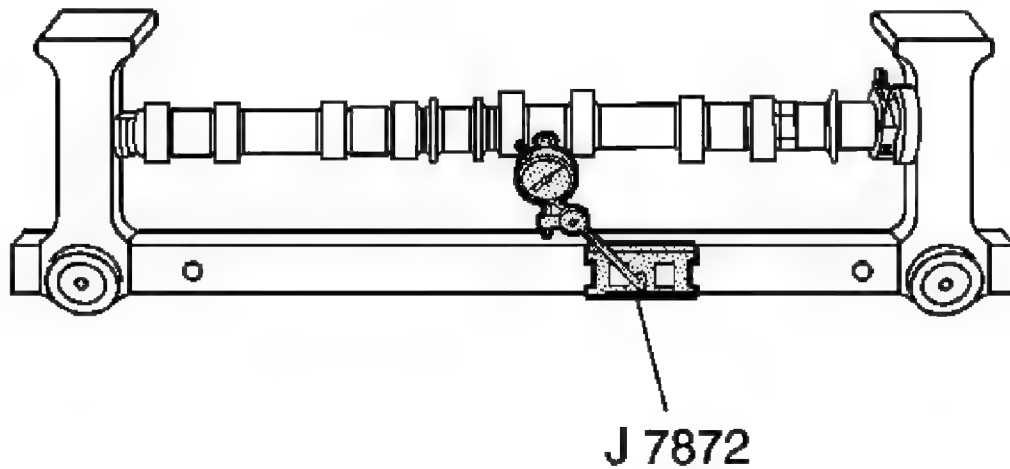


Fig. 74: Measuring Camshaft Lobes For Wear
Courtesy of GENERAL MOTORS CORP.

7. Measure the camshaft lobes for wear using the **J 7872** .

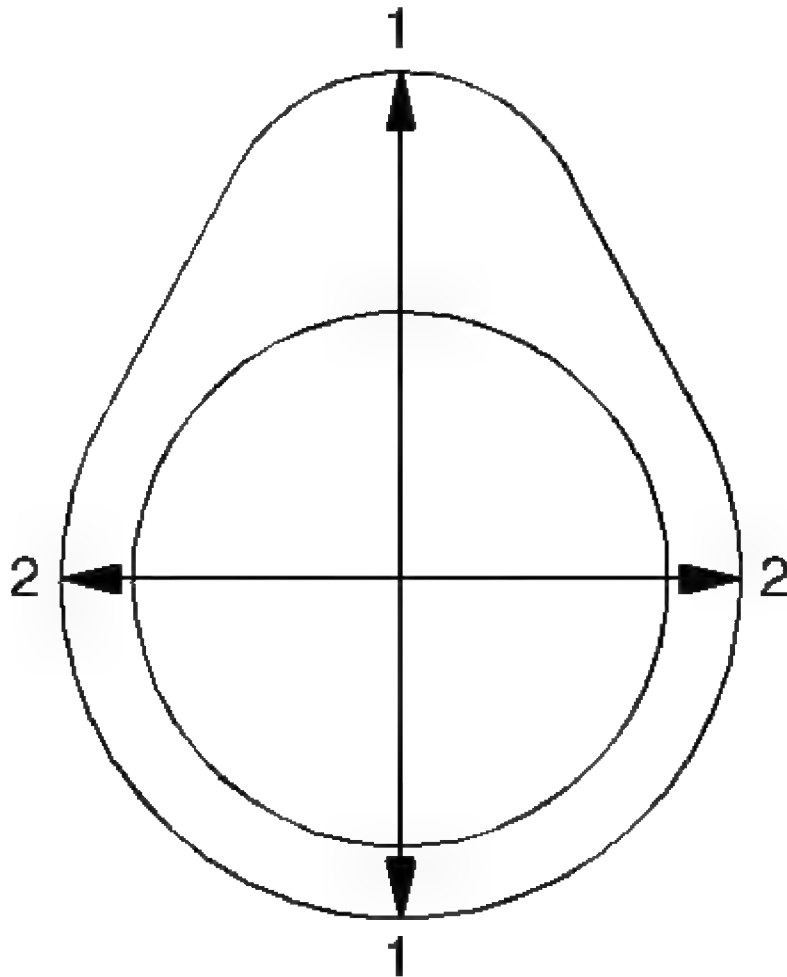


Fig. 75: Identifying Base Circle

Courtesy of GENERAL MOTORS CORP.

8. Place the **J 7872** with the indicator tip on the base circle (2) of the camshaft lobe.
 1. Place the **J 7872** dial at zero.
 2. Rotate the camshaft until the indicator tip is at the highest point on the lobe. This reading is the lift (1) of the camshaft lobe.
 3. The specifications for lift are as follows:
 - Intake camshaft: 6.154 mm (0.2423 in)
 - Exhaust camshaft: 5.944 mm (0.2336 in)
9. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

VALVE LIFTERS CLEANING AND INSPECTION

INSPECTION PROCEDURE

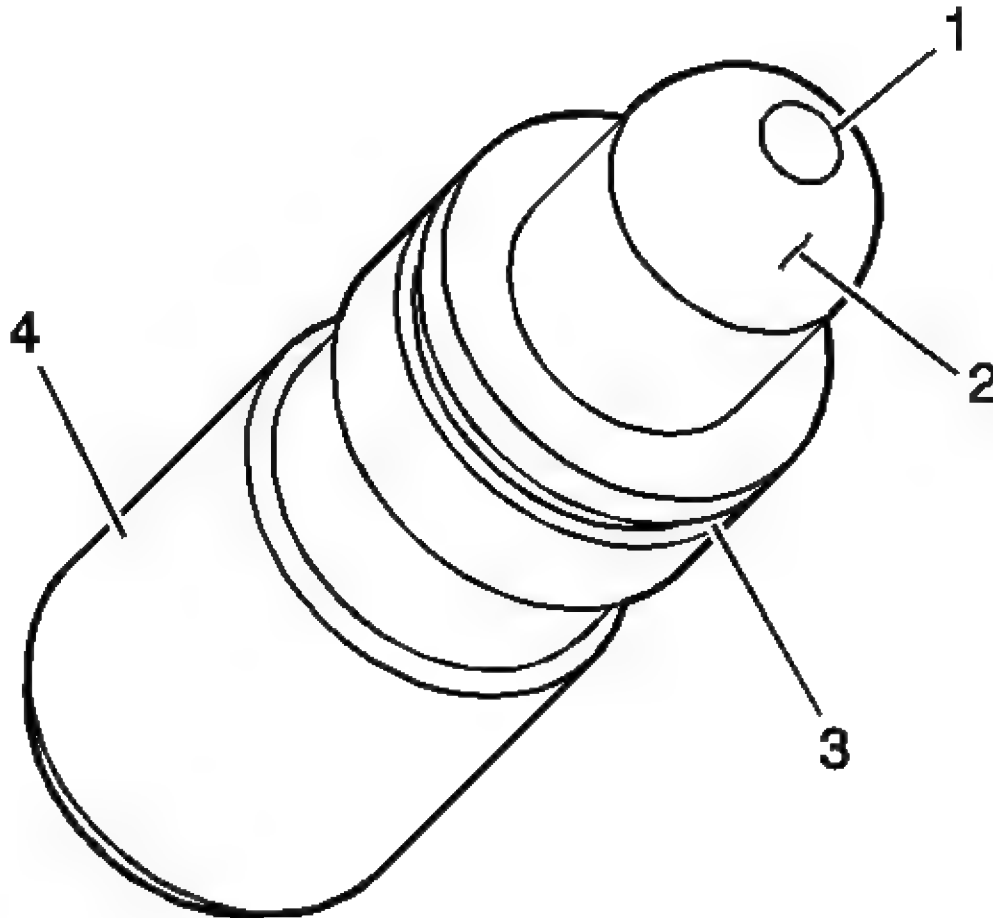


Fig. 76: Identifying Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to VALVE LIFTER PRIMING NOTICE .

1. Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas:
 - A plugged oil passage (1)
 - A scored or worn camshaft follower pivot area (2)
 - A damaged or broken retainer (3), some applications
 - A severely scuffed or worn SHLA body (4)

2. Replace the SHLA or SHLAs as necessary.

VALVE ROCKER ARMS CLEANING AND INSPECTION

CLEANING & INSPECTION PROCEDURE

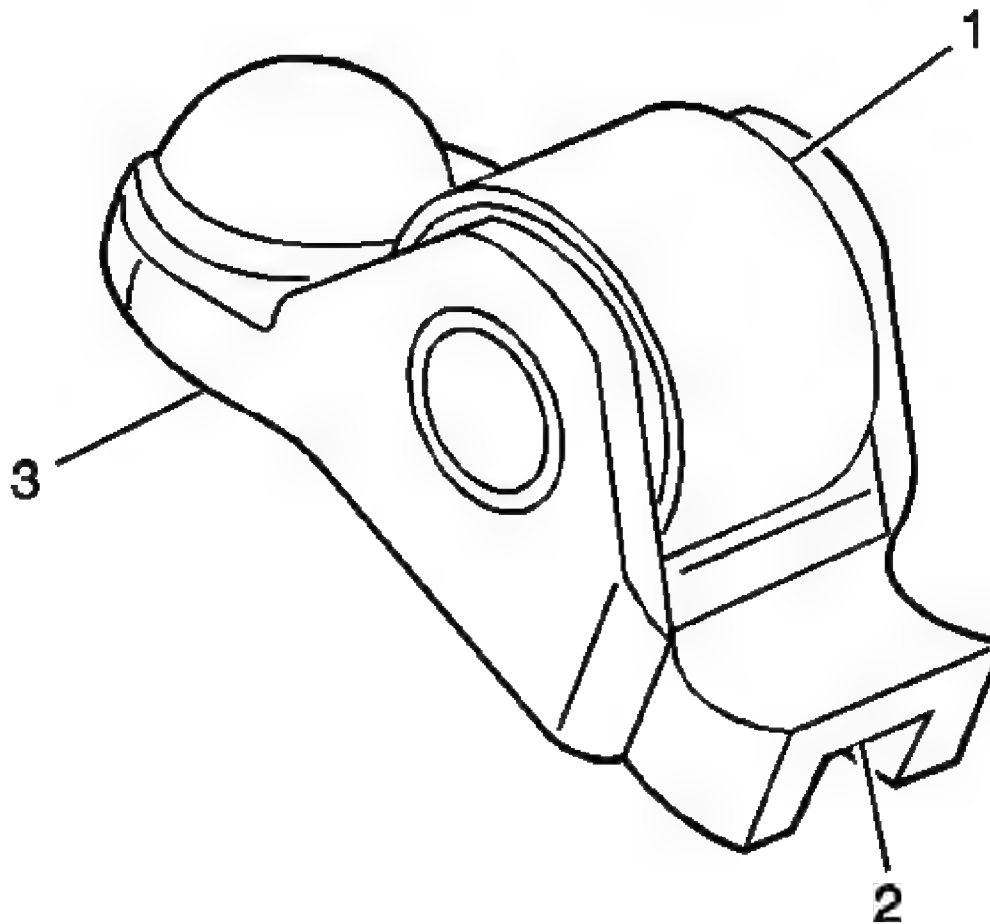


Fig. 77: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft follower roller (1) for the following:
 - Flat spots
 - Excessive scoring and pitting
 - Ensure the roller spins freely
2. Inspect the camshaft follower valve tip area (2).

3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean all the following components with solvent:

- Camshaft sprockets
- Intermediate sprocket
- Crankshaft sprocket
- Primary timing chain
- Secondary timing chains
- Primary timing chain guide
- Secondary timing chain guides
- Primary timing chain shoe
- Secondary timing chain shoes
- Primary timing chain tensioner
- Secondary timing chain tensioners
- Timing component fastening bolts

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the timing components with compressed air.

VISUAL INSPECTION

Camshaft Sprockets

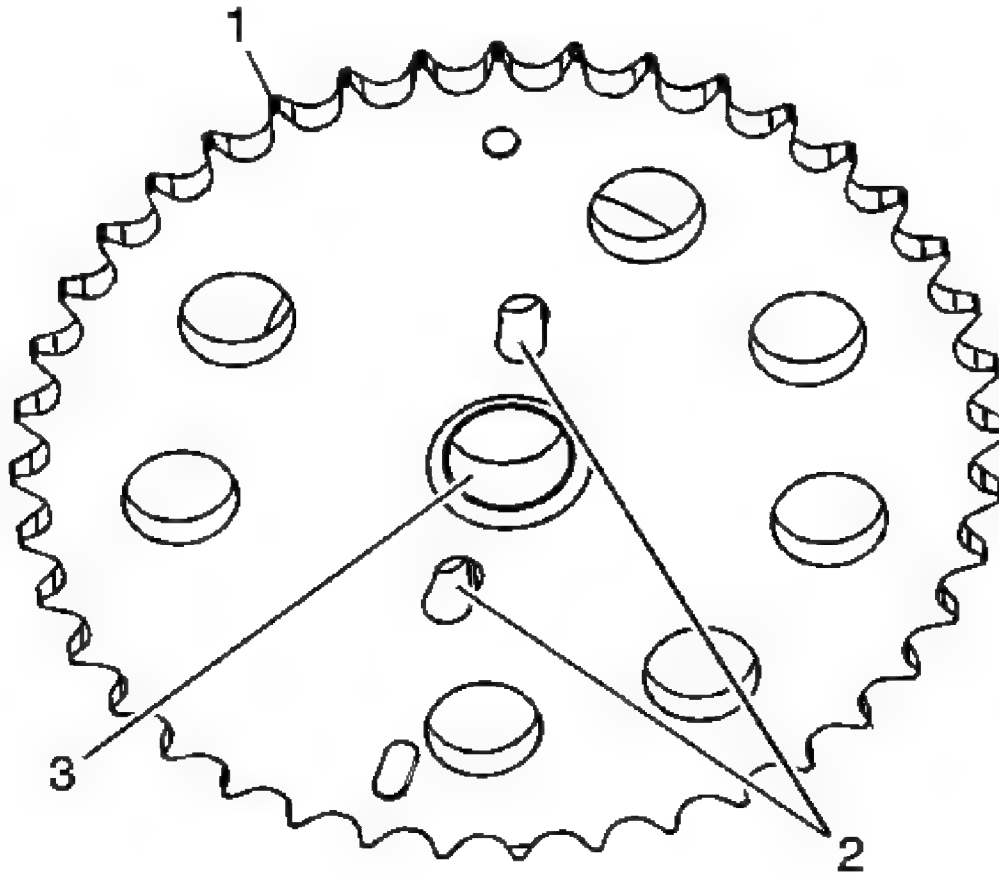


Fig. 78: View Of Inspection Areas Of Front Of Left Exhaust & Intake Camshaft Sprockets

Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the left exhaust and intake camshaft sprockets for the following:
 - Sprocket damage (1)
 - Camshaft locating pin hole damage (2)
 - Mounting bolt hole damage (3)

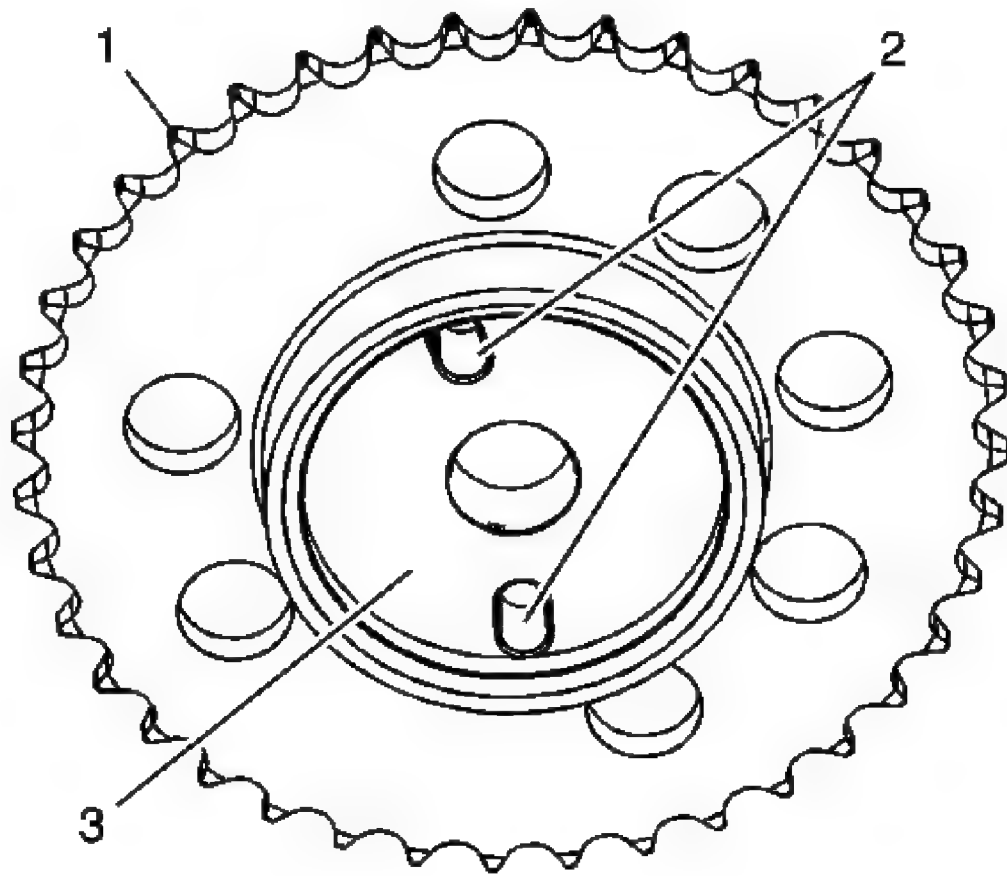


Fig. 79: View Of Inspection Areas Of Back Of Left Exhaust & Intake Camshaft Sprockets

Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the left exhaust and intake camshaft sprockets for the following:
 - Sprocket damage (1)
 - Camshaft locating pin hole (2)
 - Camshaft seating/sealing inner hub flange damage (3)

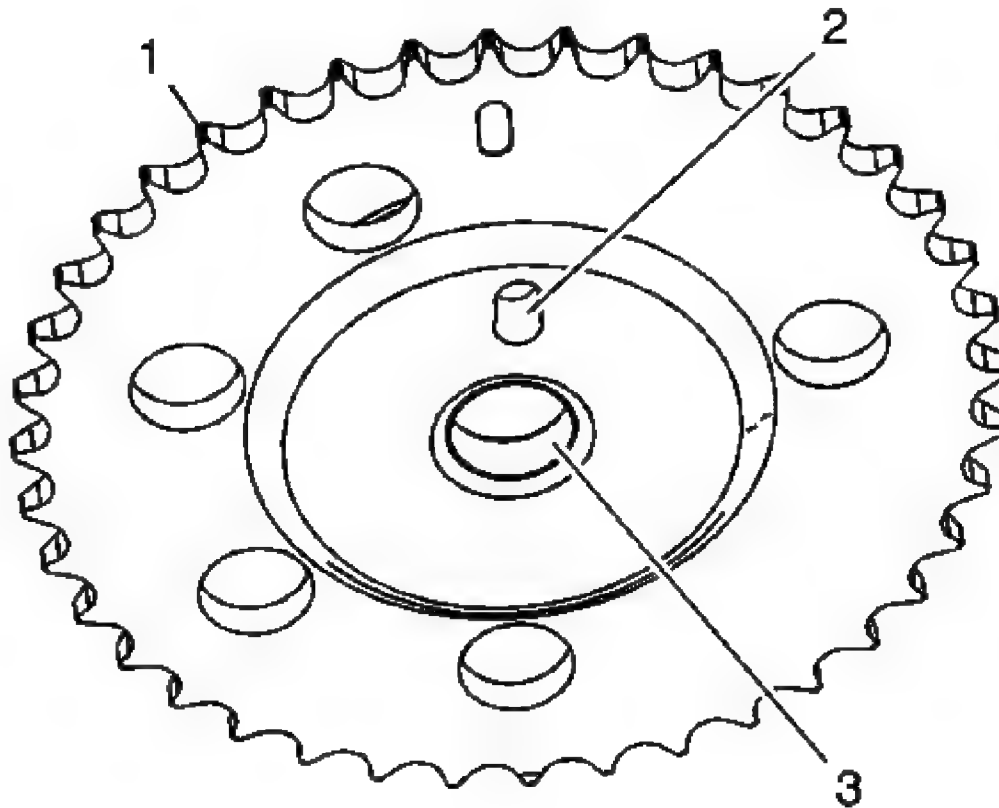


Fig. 80: View Of Inspection Areas Of Front Of Right Intake Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Inspect the front of the right exhaust camshaft sprocket for the following:
 - Sprocket damage (1)
 - Camshaft locating pin hole damage (2)
 - Mounting bolt hole damage (3)

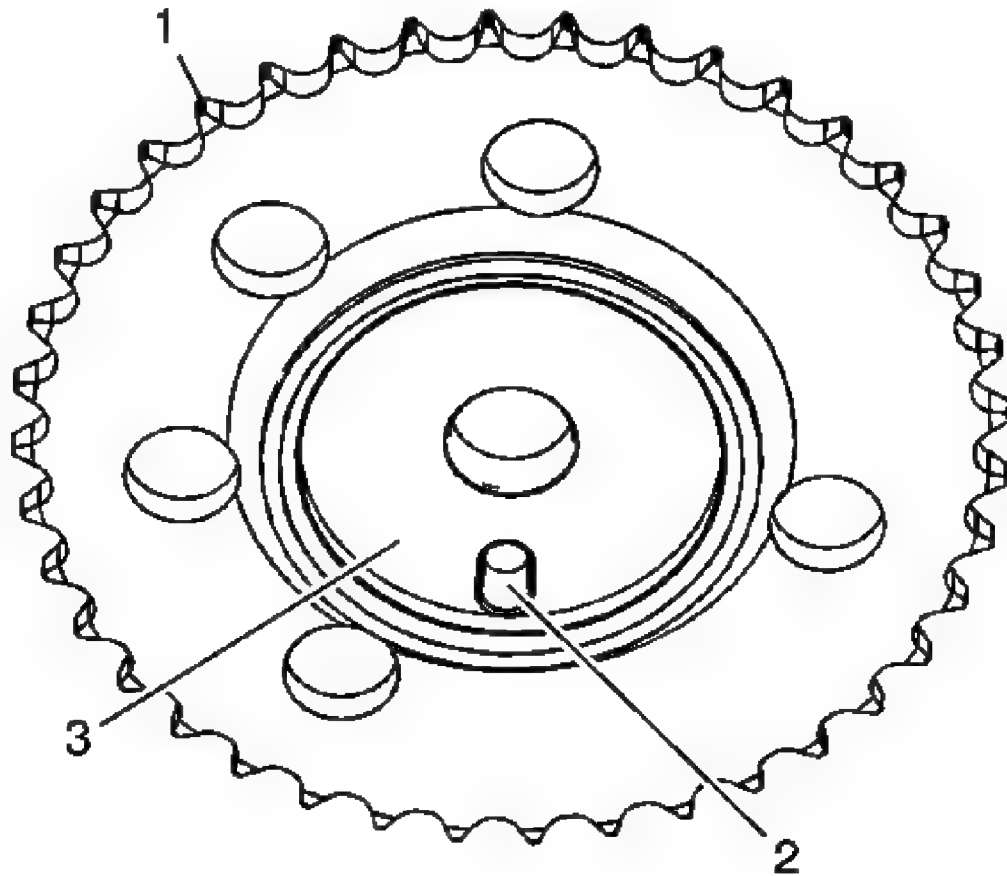


Fig. 81: View Of Inspection Areas Of Back Of Right Intake Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Inspect the back of the right exhaust camshaft sprocket for the following:
 - Sprocket damage (1)
 - Camshaft locating pin hole (2)
 - Camshaft seating/sealing inner hub flange damage (3)

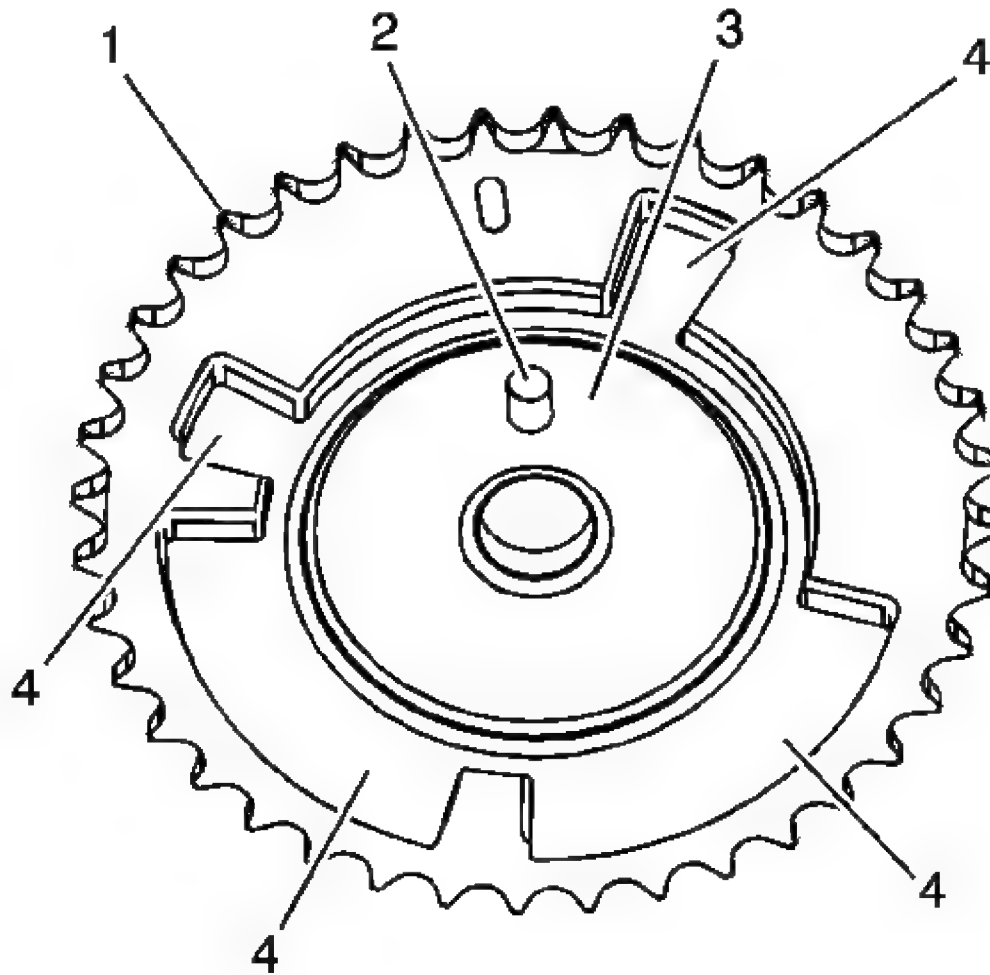


Fig. 82: View Of Front Of Right Intake Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Inspect the front of the right intake camshaft sprocket for the following:
- Sprocket damage (1)
 - Camshaft locating pin hole damage (2)
 - Mounting bolt hole damage (3)
 - Camshaft position sensing features (4)

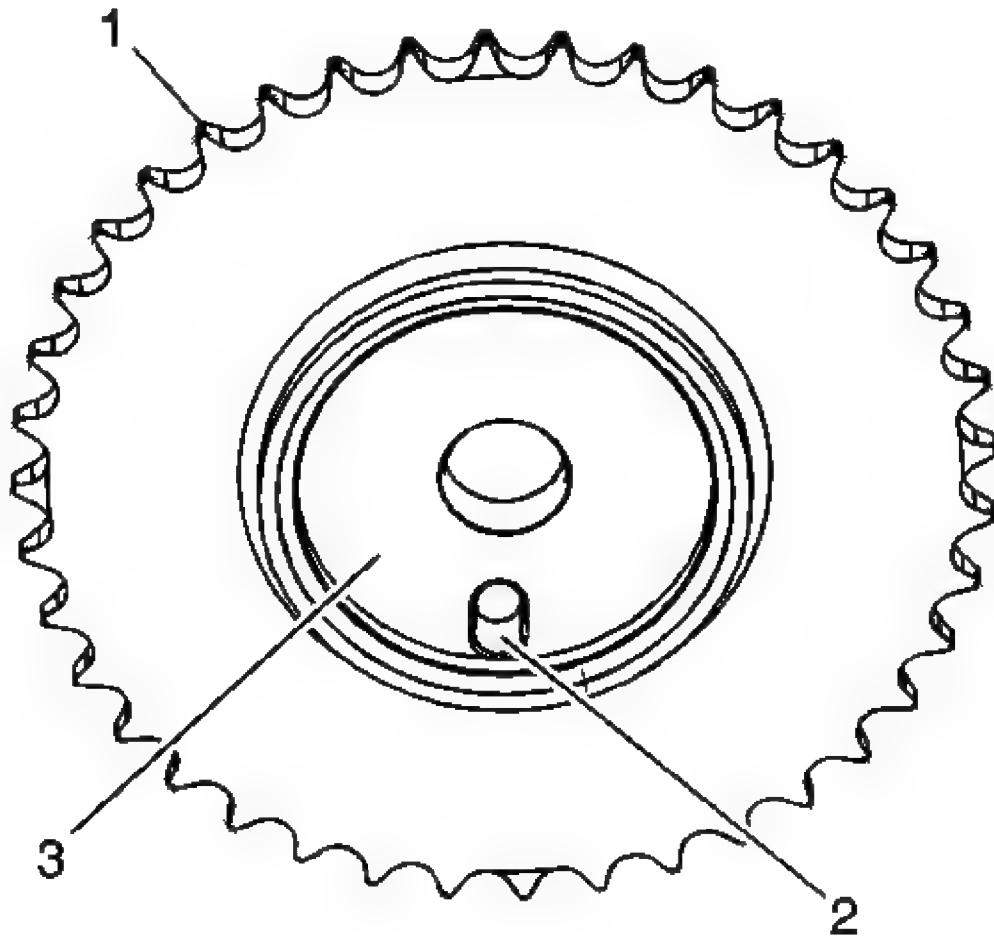


Fig. 83: View Of Back Of Right Intake Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Inspect the back of the right intake camshaft sprocket for the following:
 - Sprocket damage (1)
 - Camshaft locating pin hole (2)
 - Camshaft seating/sealing inner hub flange damage (3)
7. Replace a damaged camshaft position actuator.

Intermediate Sprocket

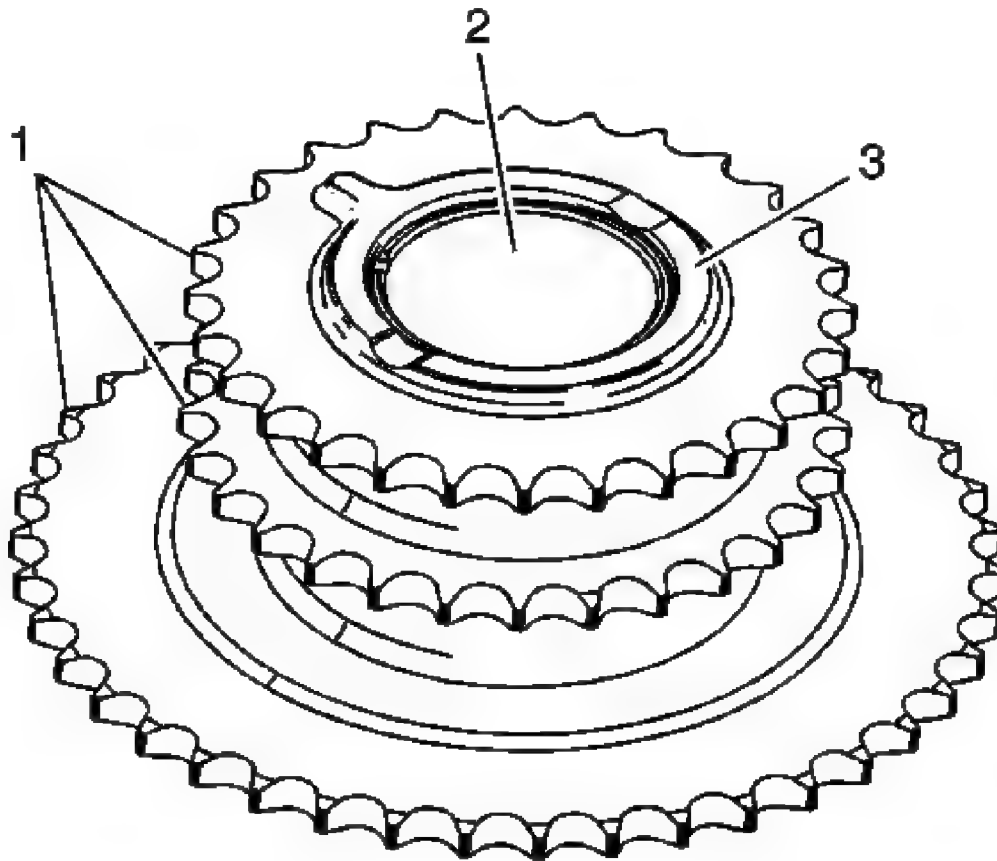


Fig. 84: View Of Inspection Areas Of Front Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the intermediate sprocket for the following:
 - Sprocket damage (1)
 - Bearing bore damage (2)
 - Thrust surface damage (3)

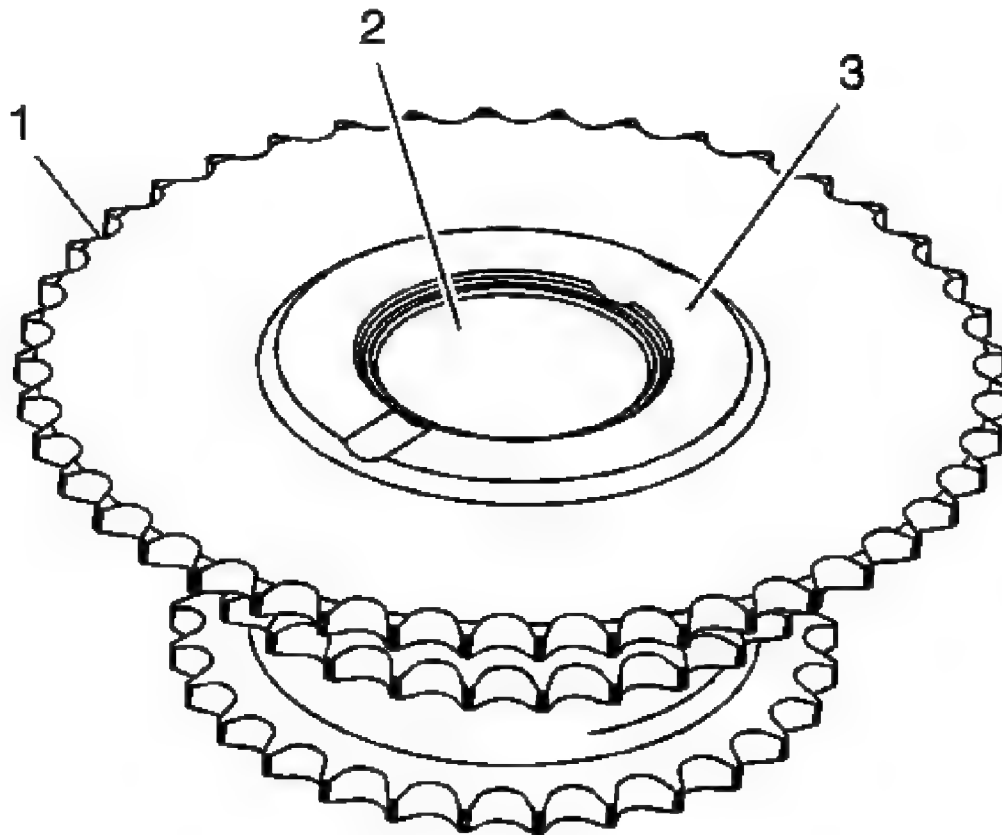


Fig. 85: View Of Inspection Areas Of Back Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the intermediate sprocket for the following:
 - Sprocket damage (1)
 - Bearing bore damage (2)
 - Thrust surface damage (3)
3. Replace a damaged intermediate sprocket.

Crankshaft Sprocket

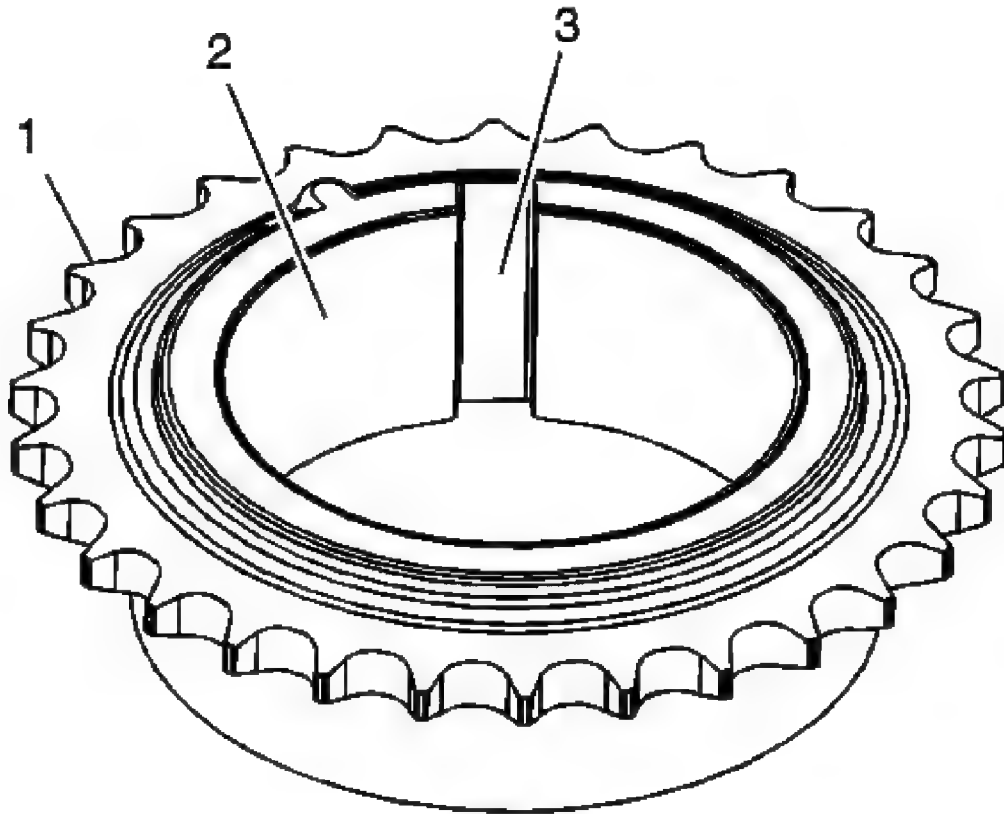


Fig. 86: View Of Inspection Areas Of Crankshaft Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the intermediate sprocket for the following:
 - Sprocket damage (1)
 - Bore damage (2)
 - Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

Primary and Secondary Timing Chains

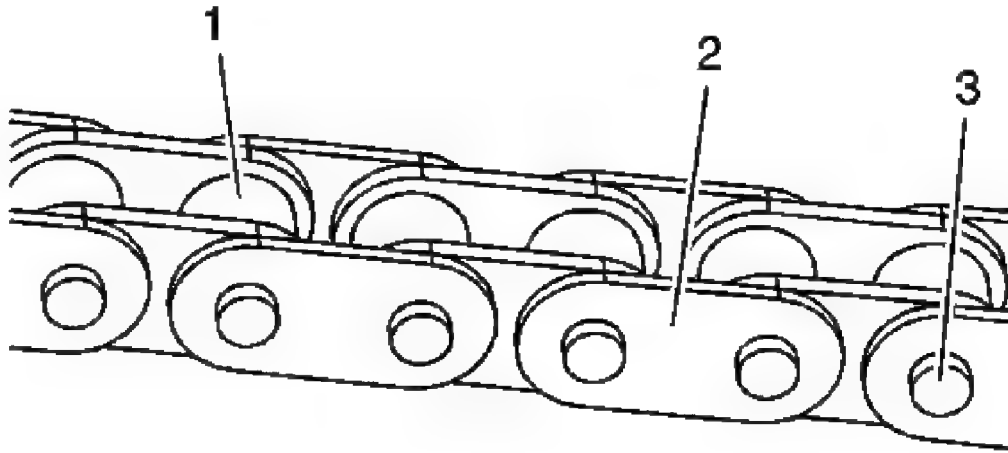


Fig. 87: View Of Inspection Areas Of Primary & Secondary Timing Chain
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary and/or secondary timing chain for the following:
 - Binding or worn rollers (1)
 - Loose links (2)
 - Loose pins (3)
2. Replace a damaged primary and/or secondary timing chains.

Primary Timing Chain Guide

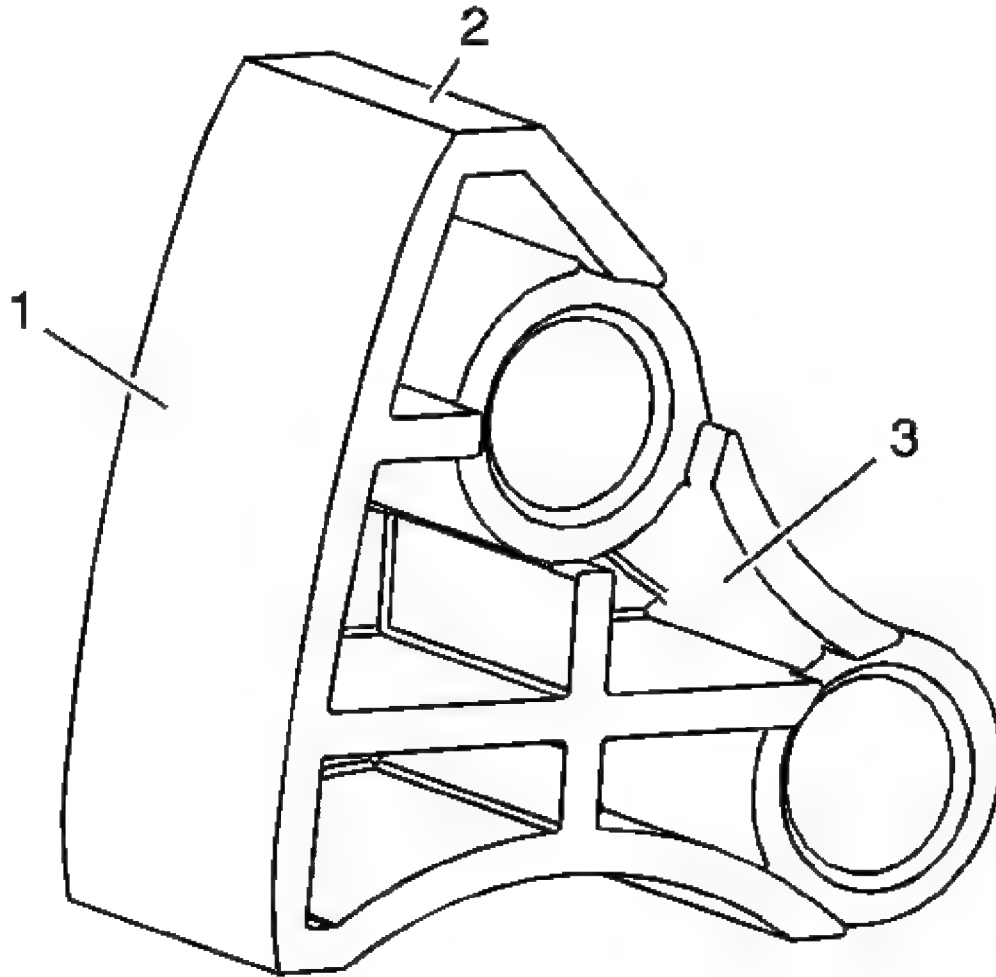


Fig. 88: View of Primary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain guide for the following:
 - Worn guide surface (1)
 - Cracked or broken guide surface (2)
 - Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain guide.

Secondary Timing Chain Guides

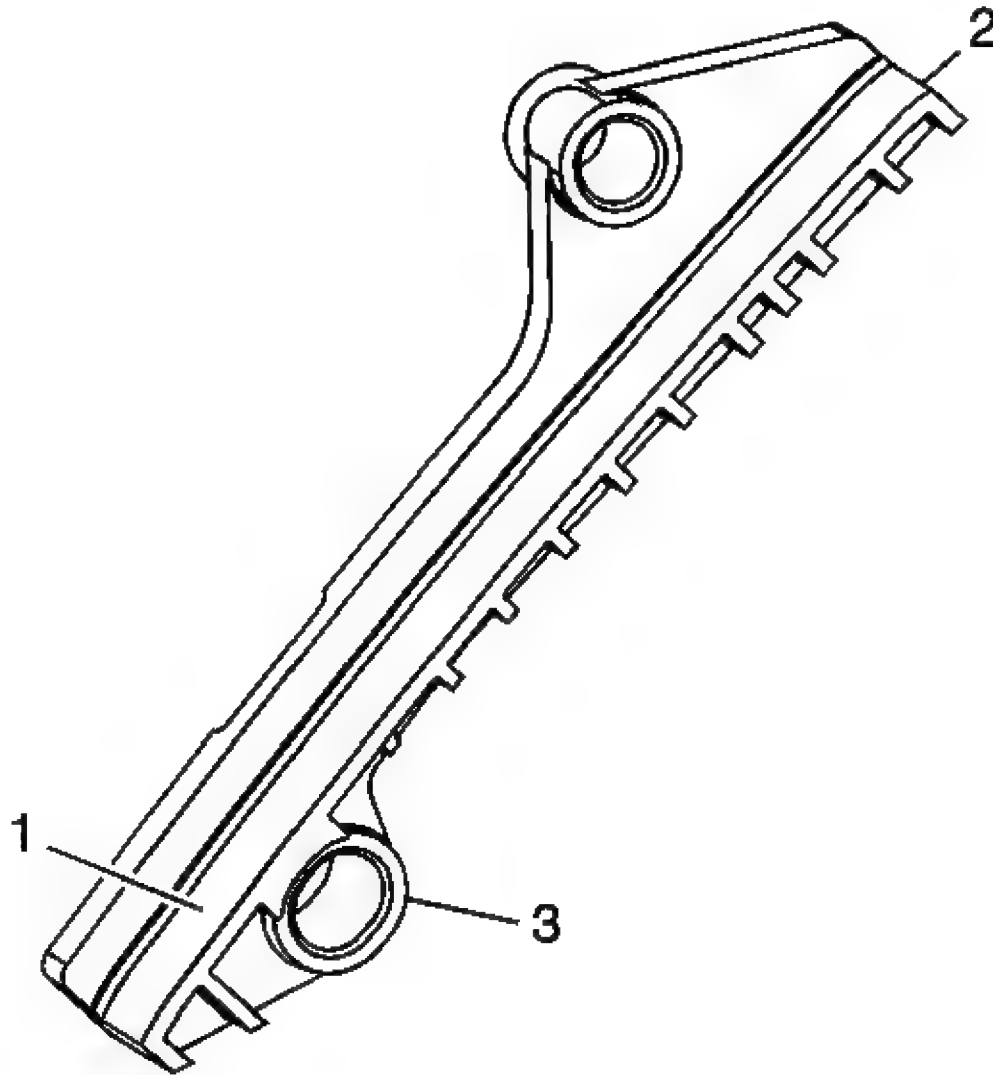


Fig. 89: View of Secondary Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

1. Inspect the secondary timing chain guides for the following:
 - Worn guide surface (1)
 - Cracked or broken guide surface (2)
 - Cracked or damaged guide base (3)
2. Replace a damaged secondary timing chain guide.

Secondary Timing Chain Shoes

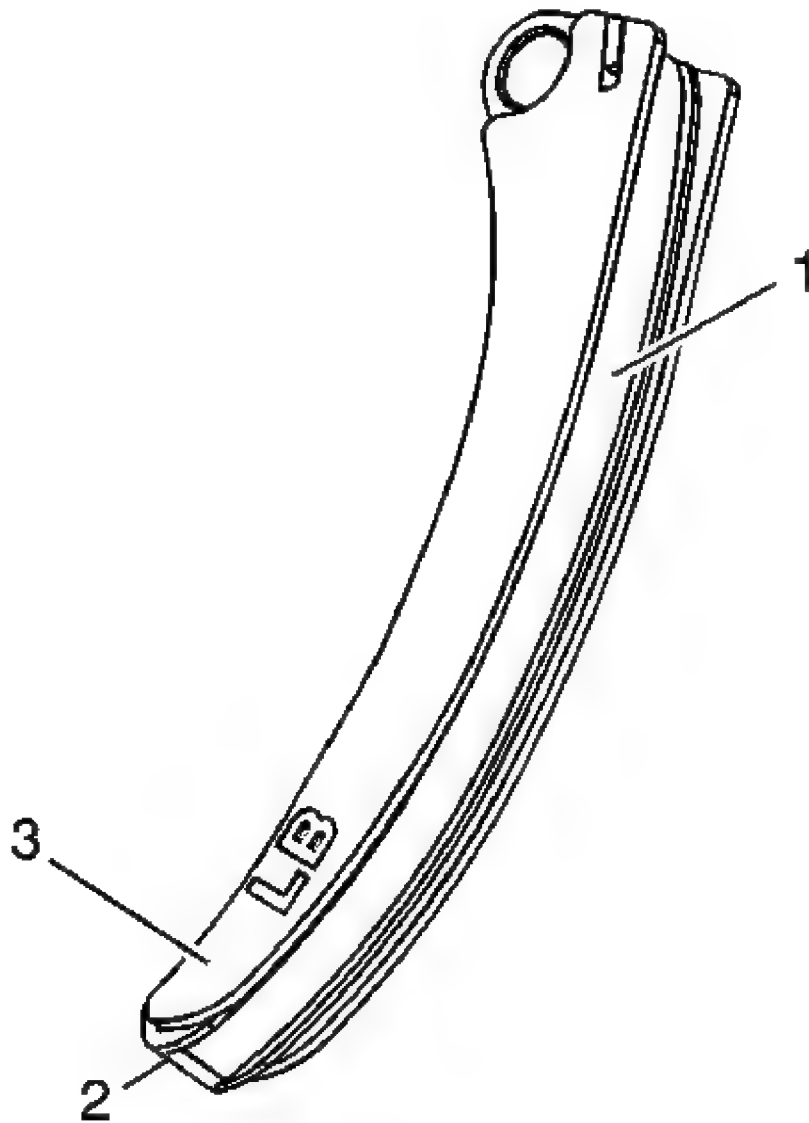


Fig. 90: View of Secondary Timing Chain Shoes
Courtesy of GENERAL MOTORS CORP.

1. Inspect the secondary timing chain shoes for the following:
 - Worn shoe surface (1)
 - Cracked or broken shoe surface (2)
 - Cracked or damaged shoe (3)
2. Replace a damaged secondary timing chain shoe.

Primary Timing Chain Tensioner

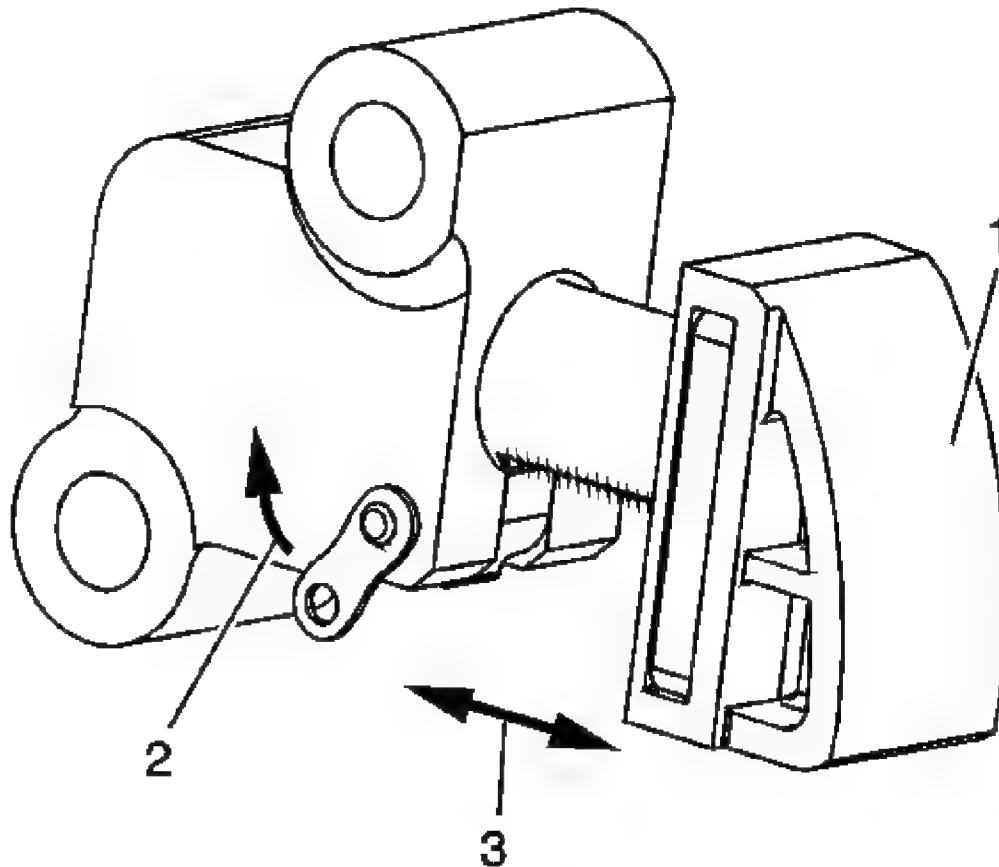


Fig. 91: View of Primary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).
2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Release the locking lever (2) and ensure the plunger moves freely (3) in and out of the body of the tensioner.
3. Replace a damaged primary timing chain tensioner.

Secondary Timing Chain Tensioners

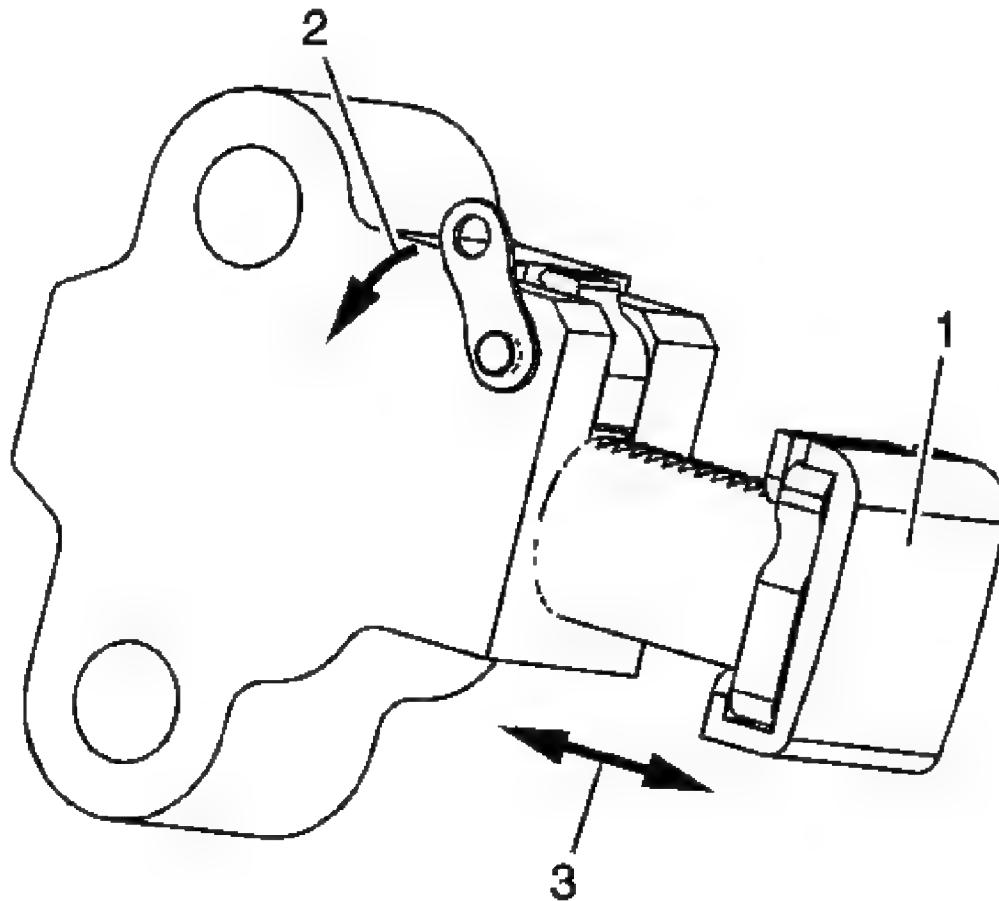


Fig. 92: View of Secondary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the secondary timing chain tensioner for locked or binding timing chain tensioner. Release the locking lever (2) and ensure the plunger moves freely (3) in and out of the body of the tensioner.
3. Replace a damaged primary and/or secondary timing chain tensioner.

Timing Component Fasteners

1. Inspect the timing component fasteners.
2. Replace any damaged timing component fasteners, do not repair.

OIL PUMP DISASSEMBLE

DISASSEMBLY PROCEDURE

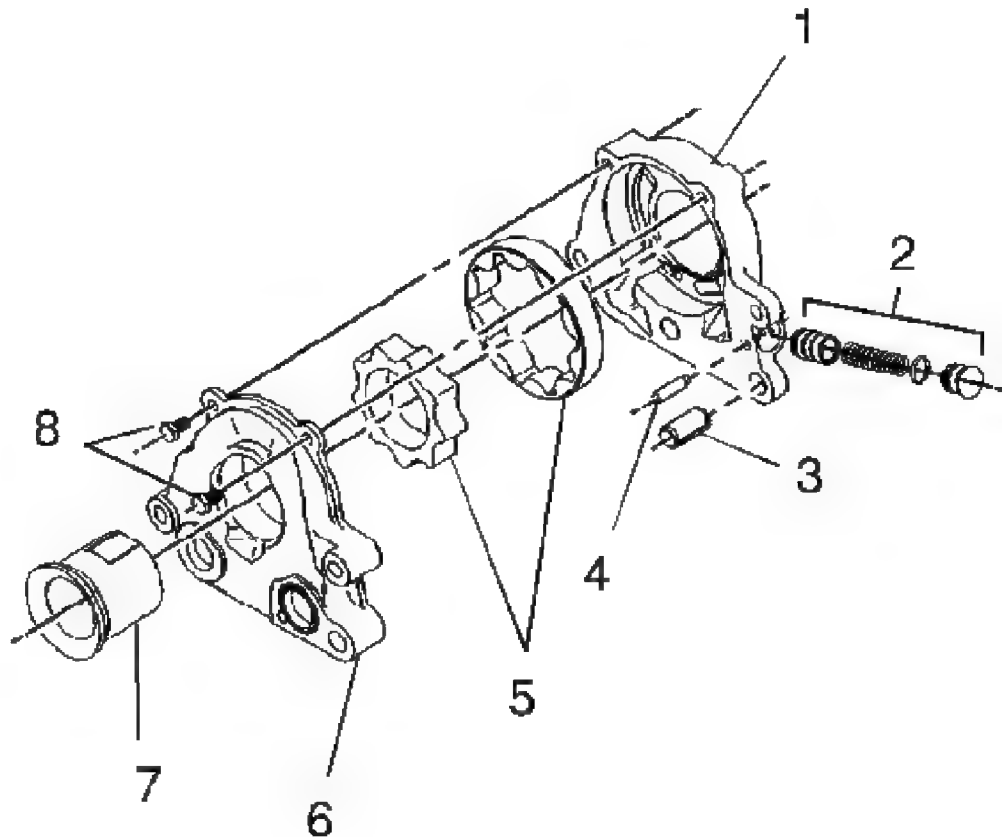


Fig. 93: View of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive spacer (7) from the oil pump housing.
2. Remove the two screws (8) holding the pump housing halves (6, 1) together.
3. Remove the inner (drive) and the outer (driven) rotors (5) from the housing. Note the orientation of the pump rotors. The outer rotor has one chamfered edge. The chamfered edge must be face-down (closest to the rear of the engine) in the pump body (1).
4. Remove the oil pressure relief valve (2) as follows:
 1. Remove the pressure relief valve cap retaining pin (4).
 2. Remove the retaining plug without damaging the O-ring seal.
 3. Slide the pressure relief valve spring and piston out of its bore.

OIL PUMP CLEANING AND INSPECTION

CLEANING PROCEDURE

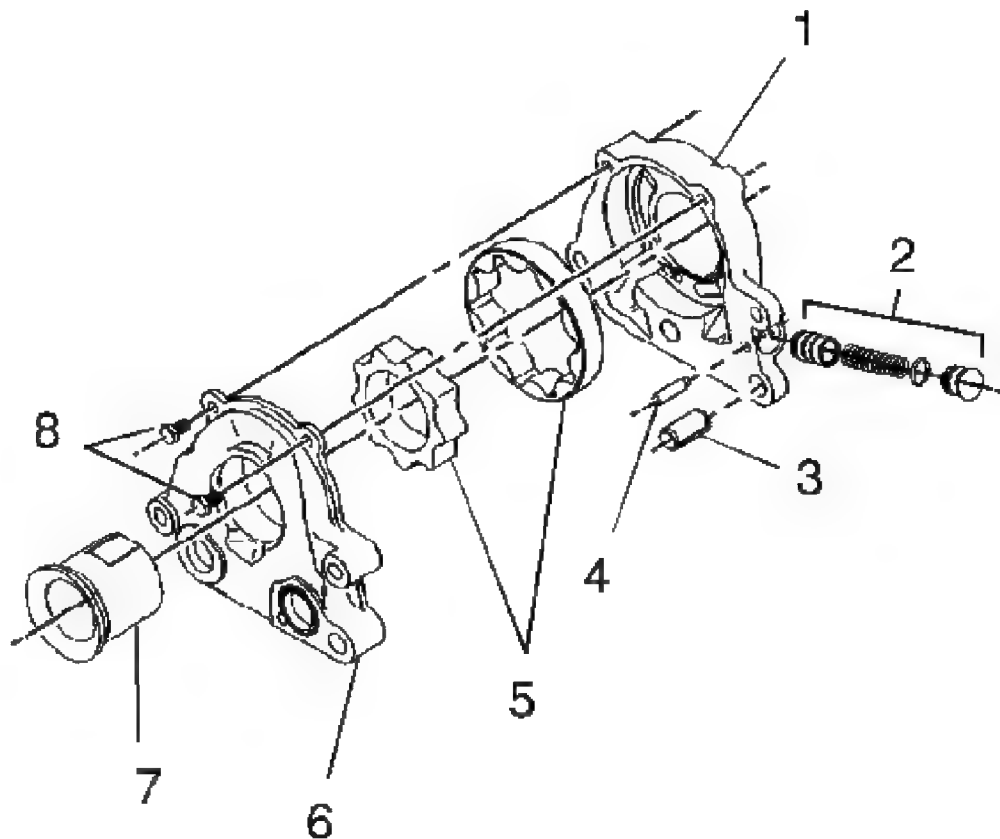


Fig. 94: View of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

1. Clean the oil pump components (1-8) with non-corrosive solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the oil pump components with compressed air.

INSPECTION PROCEDURE

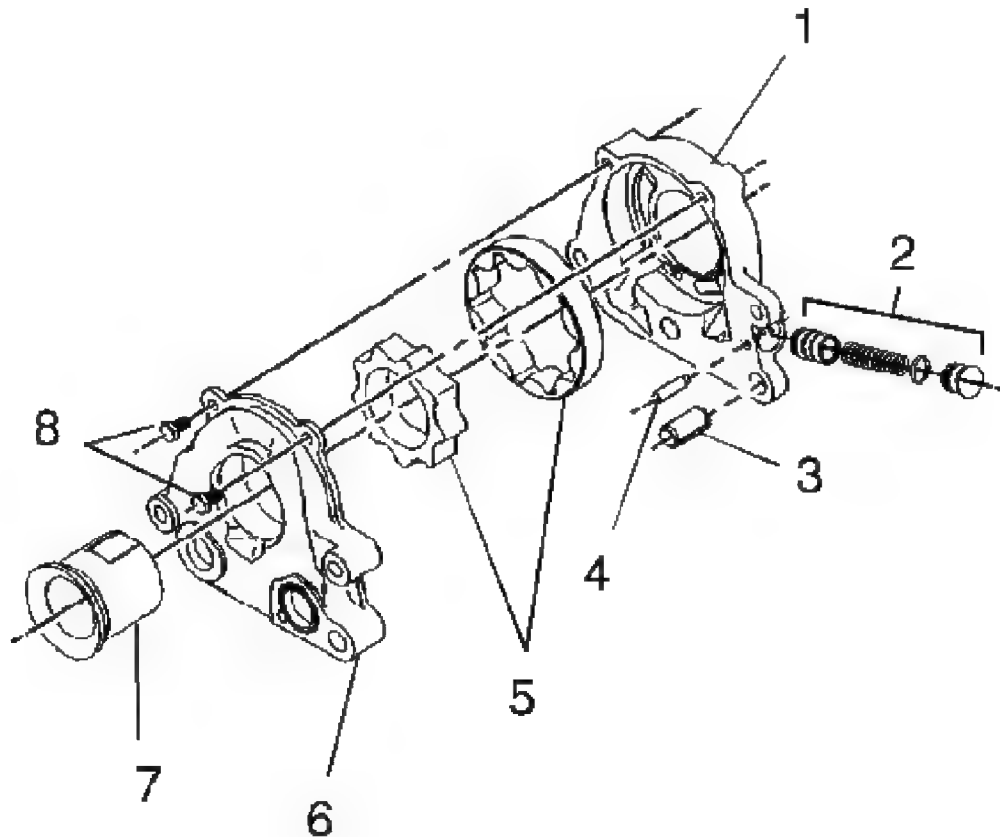


Fig. 95: View of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The internal parts of the oil pump are not serviced separately. If wear or damage is noted, replace the entire pump assembly.

1. Clean the oil pump components with non-corrosive solvent.
2. Inspect the housing (1) and the cover (6) for cracks, scoring, casting imperfections and damaged threads.
3. Inspect the gerotor gears (5) for chipping, galling or wear.
4. Inspect the pressure relief valve (2) for embedded particles and/or damage.

OIL PUMP ASSEMBLE

ASSEMBLY PROCEDURE

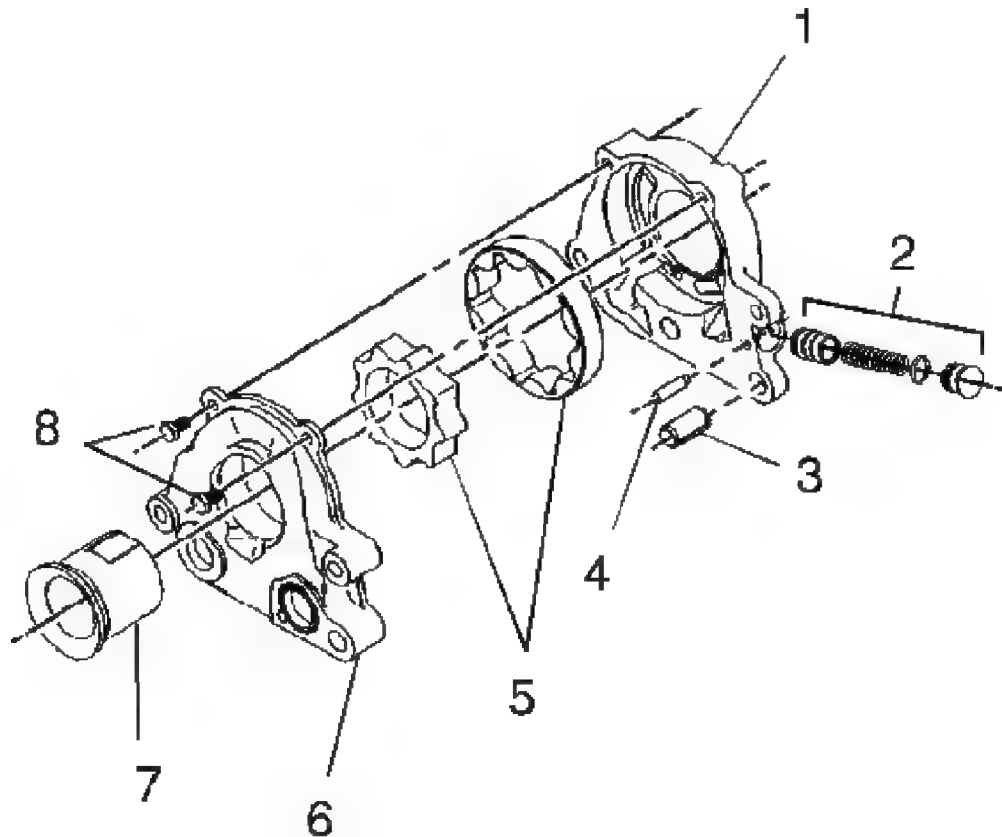


Fig. 96: View of Oil Pump Components
Courtesy of GENERAL MOTORS CORP.

1. Install the inner and the outer rotors (5) in the pump cover in the same orientation as removed. The outer rotor has one chamfered edge. The chamfered edge must be face-down (closest to the rear of the engine) in the pump body (1).
2. Install the pressure relief valve piston, spring and retaining cap (2) in the pump housing bore.
3. Install the pressure relief valve cap retaining pin (4).
4. Pack the pump housing with white petroleum jelly to ensure pump priming.
5. Assemble the housing and cover over the locating dowel (3).
6. Insert a 9.5 mm (0.375 in) drill in the pump mounting hole on the opposite side in order to aid in the alignment of the housing and cover.

NOTE: Refer to SPECIAL FASTENER NOTICE .

7. Install the oil pump cover bolts (8).

Tighten: Tighten the oil pump cover bolts to 12 N.m (106 lb in).

OIL FILTER ADAPTER DISASSEMBLE (WITHOUT OIL COOLER)

DISASSEMBLY PROCEDURE

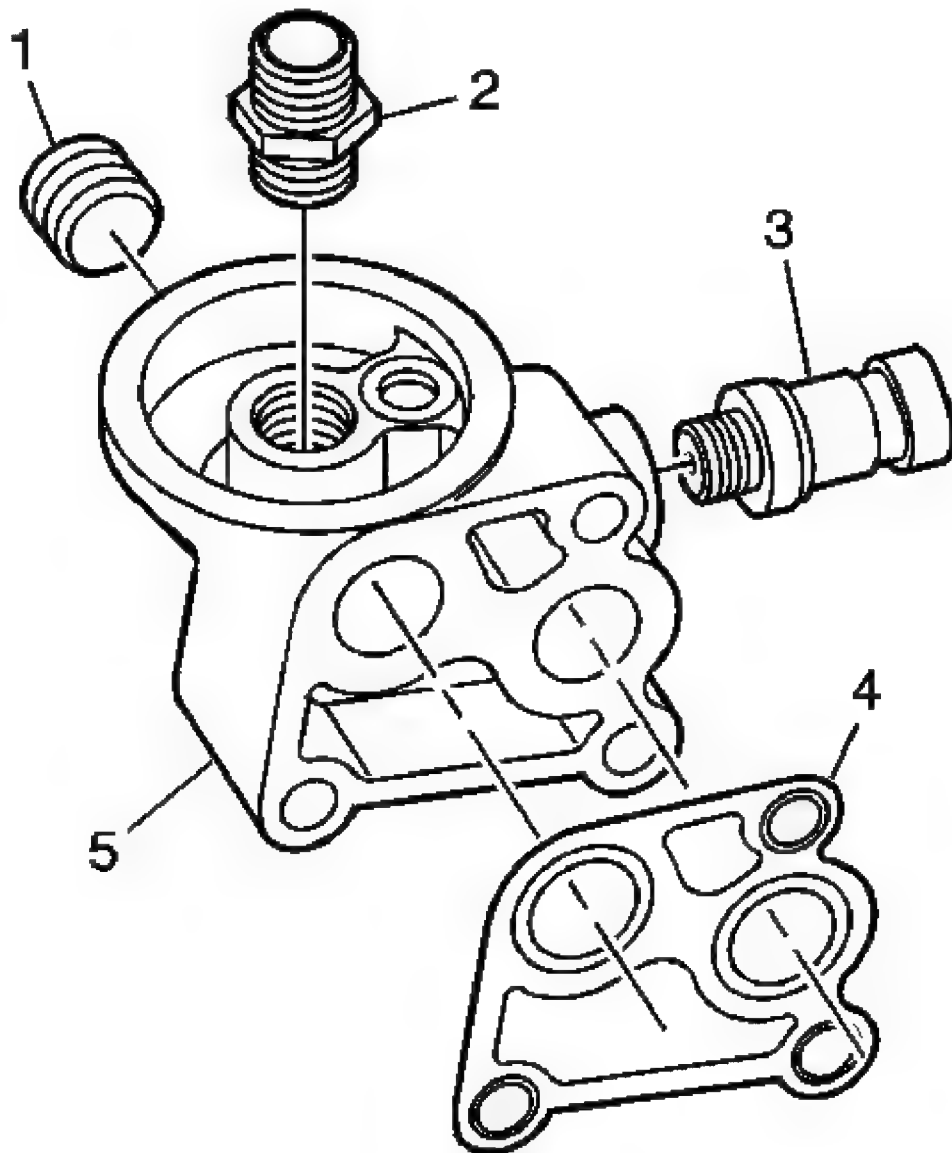


Fig. 97: Identifying Oil Filter Adapter Components (without Oil Cooler)

Courtesy of GENERAL MOTORS CORP.

1. Remove and inspect the bypass hole plug (1).
2. Remove and inspect the oil filter fitting (2).
3. Remove and inspect the oil pressure switch (3).
4. Remove and discard the oil filter adapter gasket (4).

OIL FILTER ADAPTER DISASSEMBLE (WITH OIL COOLER)

DISASSEMBLY PROCEDURE

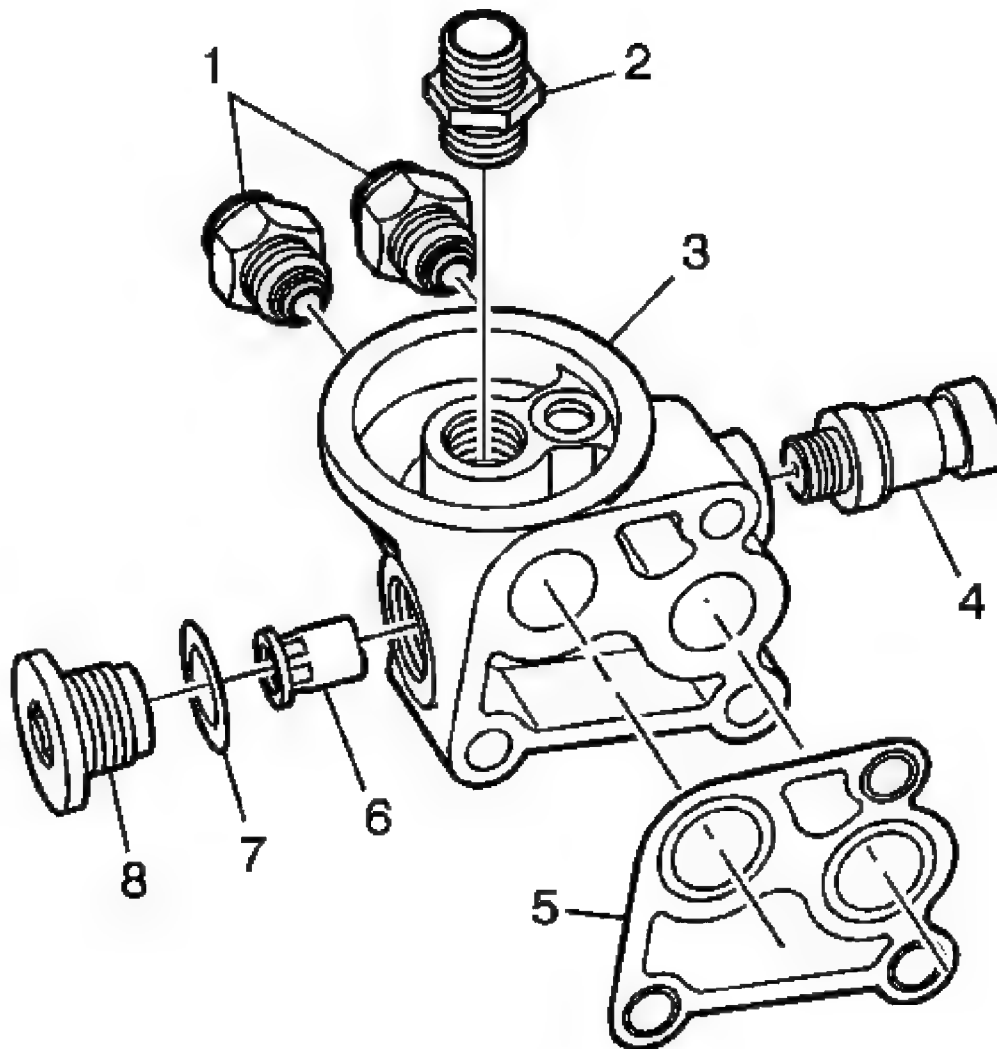


Fig. 98: Identifying Oil Filter Adapter Components (with Oil Cooler)
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the oil cooler line connector fittings (1).
2. Remove and inspect the oil filter fitting (2).
3. Remove and inspect the oil pressure switch (4).
4. Remove and discard the oil filter adapter gasket (5).
5. Remove and inspect the oil cooler bypass valve hole plug (8).
6. Remove and discard the oil cooler bypass valve hole plug O-ring (7).
7. Remove and inspect the oil cooler bypass valve (6).

OIL FILTER ADAPTER CLEANING AND INSPECTION (WITHOUT OIL COOLER)

CLEANING PROCEDURE

1. Clean the oil filter adapter in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the oil filter adapter with compressed air.

INSPECTION PROCEDURE

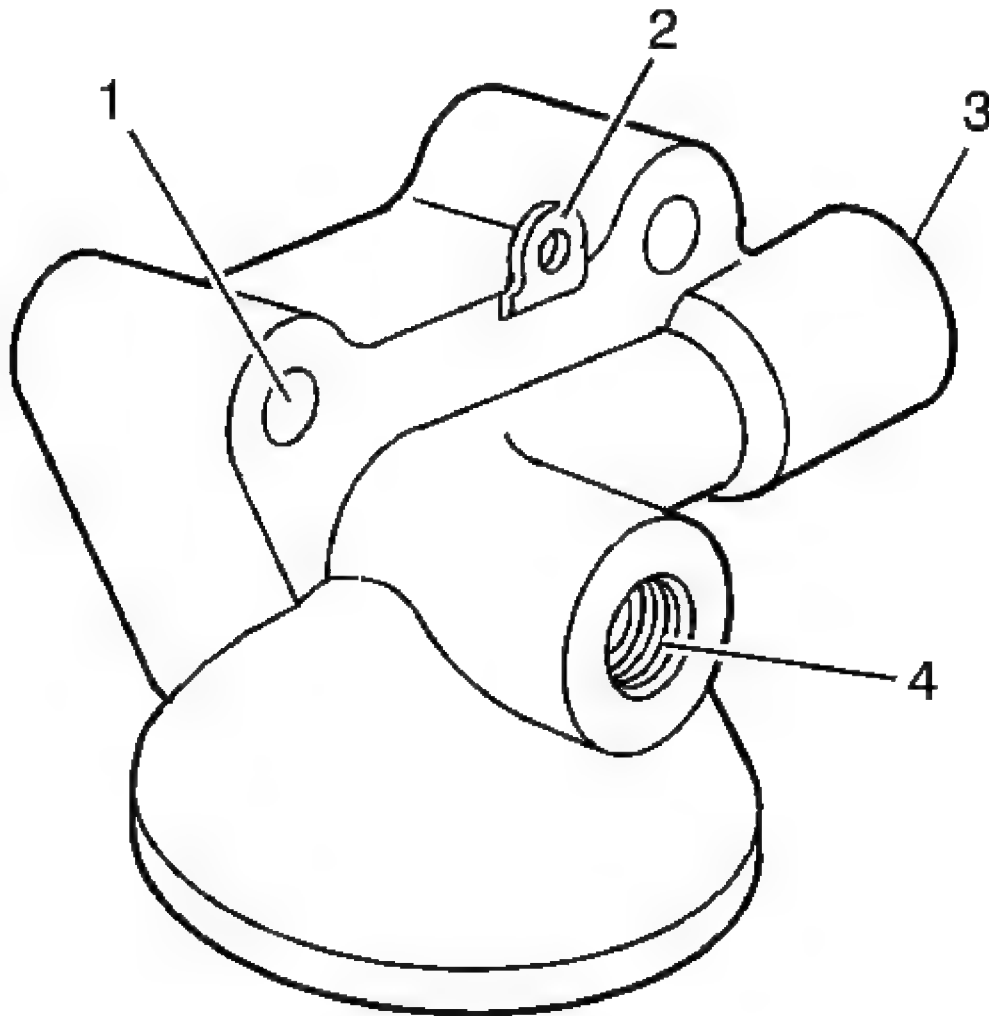


Fig. 99: View Of Inspection Areas Of Oil Filter Adapter (without Oil Cooler)
Courtesy of GENERAL MOTORS CORP.

1. Inspect the oil filter adapter for the following:
 - Damage to the wiring harness retaining tab (2)
 - Damage to the threads for the oil pressure switch (3)
 - Damage to the threads for the bypass valve hole plug (4)
 - Damage to the mounting holes (1)

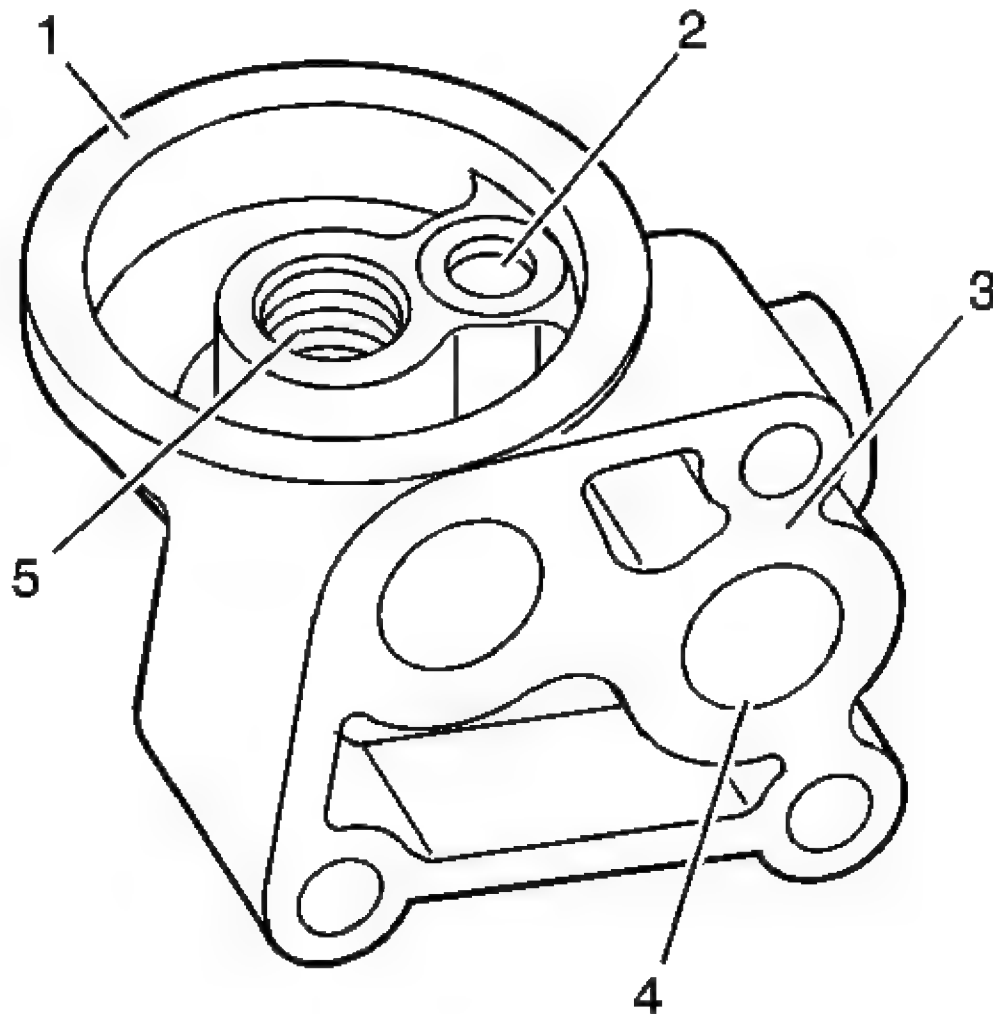


Fig. 100: View Of Additional Inspection Areas Of Oil Filter Adapter (without Oil Cooler)

Courtesy of GENERAL MOTORS CORP.

2. Inspect the oil filter adapter for the following:
 - Damage to the oil filter bypass valve (2)
 - Damage to the mounting surface (3)
 - Damage to the gasket sealing surface (4)
 - Damage to the threads for the oil filter fitting (5)
 - Damage to the oil filter sealing surface (1)
3. Inspect the passages of the oil filter adapter for blockage or obstructions.

IMPORTANT: The oil filter bypass valve is not a replaceable component, the oil filter adapter must be replaced if the oil filter bypass valve requires replacement.

4. Repair or replace components as necessary.

OIL FILTER ADAPTER CLEANING AND INSPECTION (WITH OIL COOLER)

CLEANING PROCEDURE

1. Clean the oil filter adapter in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the oil filter adapter with compressed air.

INSPECTION PROCEDURE

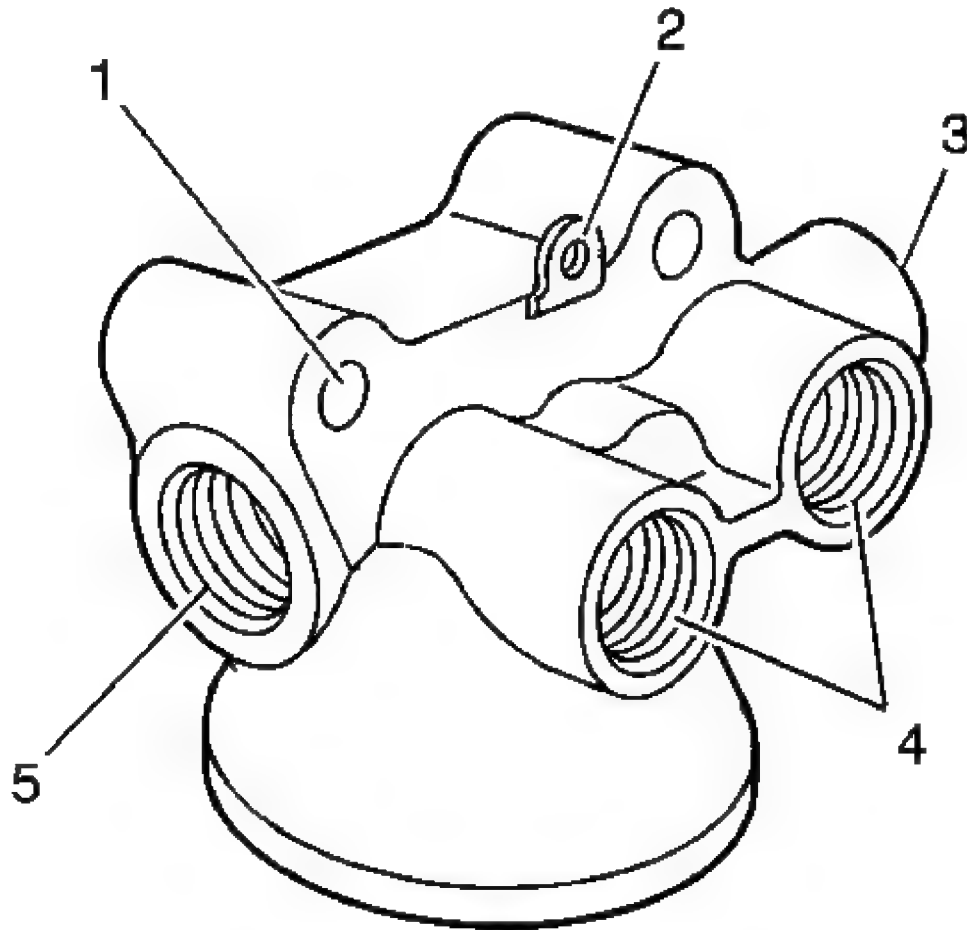


Fig. 101: View Of Inspection Areas Of Oil Filter Adapter (with Oil Cooler)
Courtesy of GENERAL MOTORS CORP.

1. Inspect the oil filter adapter for the following:
 - Damage to the wiring harness retaining tab (2)
 - Damage to the threads for the following:
 - Oil pressure switch (3)
 - Oil cooler line connector fittings (4)
 - Oil cooler bypass valve (5)
 - Damage to the mounting holes (1)

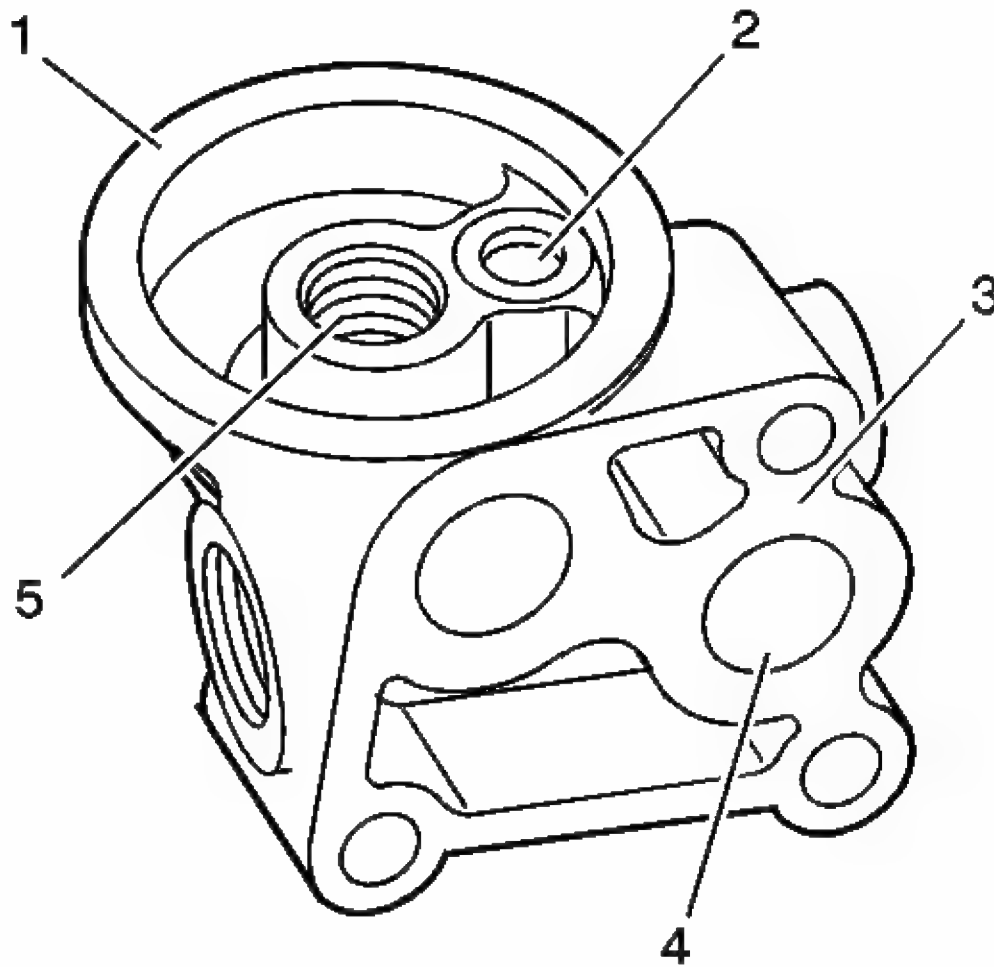


Fig. 102: View Of Additional Inspection Areas Of Oil Filter Adapter (with Oil Cooler)

Courtesy of GENERAL MOTORS CORP.

2. Inspect the oil filter adapter for the following:
 - Damage to the oil filter bypass valve (2)
 - Damage to the mounting surface (3)
 - Damage to the gasket sealing surface (4)
 - Damage to the threads for the oil filter fitting (5)
 - Damage to the oil filter sealing surface (1)
3. Inspect the passages of the oil filter adapter for blockage or obstructions.

IMPORTANT: The oil filter bypass valve is not a replaceable component, the oil filter adapter must be replaced if the oil filter bypass valve requires replacement.

4. Repair or replace components as necessary.

OIL FILTER ADAPTER ASSEMBLE (WITHOUT OIL COOLER)

ASSEMBLY PROCEDURE

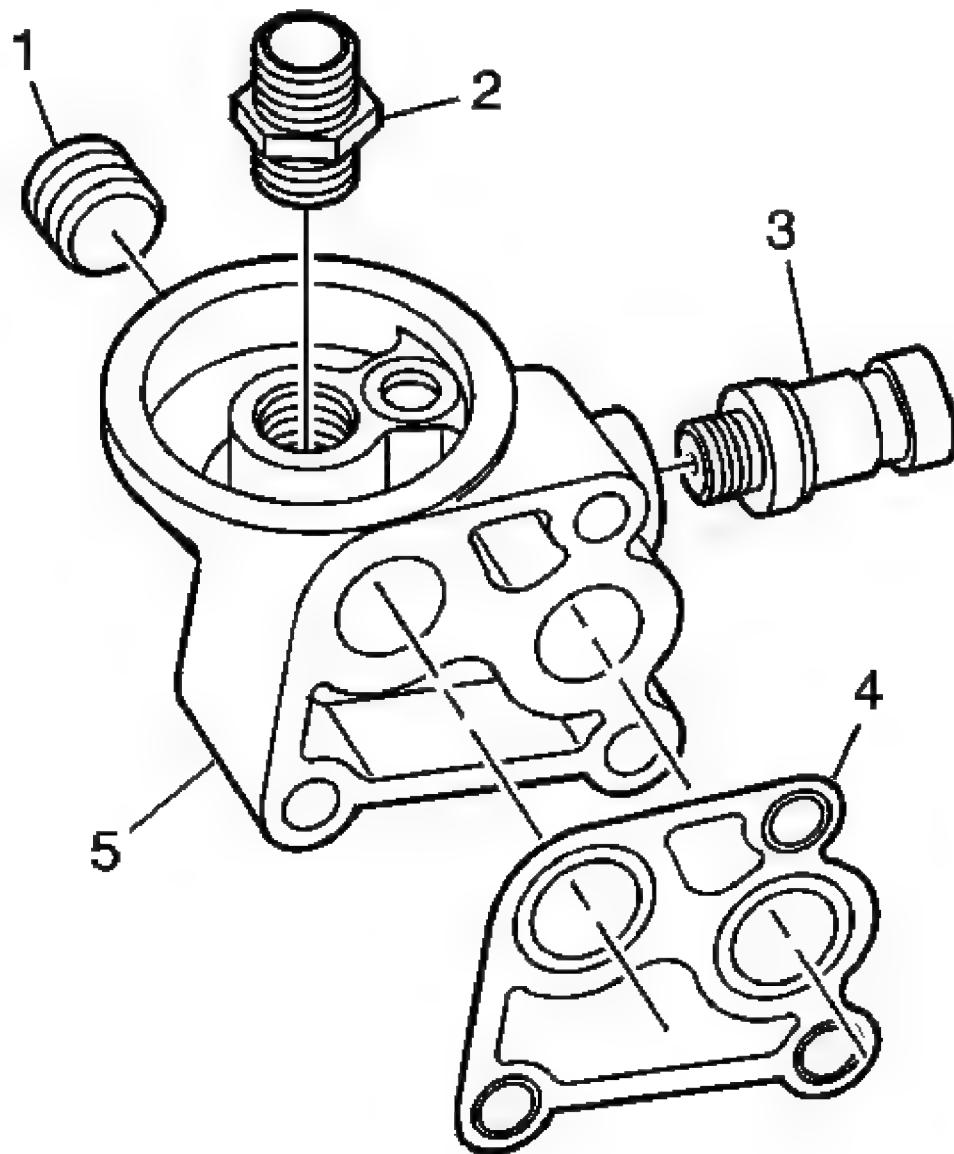


Fig. 103: Identifying Oil Filter Adapter Components (without Oil Cooler)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the bypass hole plug (1).

Tighten: Tighten the bypass hole plug to 20 N.m (15 lb ft).

2. Install the oil filter fitting (2).

Tighten: Tighten the oil filter fitting to 29 N.m (21 lb ft).

3. Install the oil pressure switch (3).

Tighten: Tighten the oil pressure switch to 16 N.m (12 lb ft).

4. Install the NEW oil filter adapter gasket (4).

OIL FILTER ADAPTER ASSEMBLE (WITH OIL COOLER)

ASSEMBLY PROCEDURE

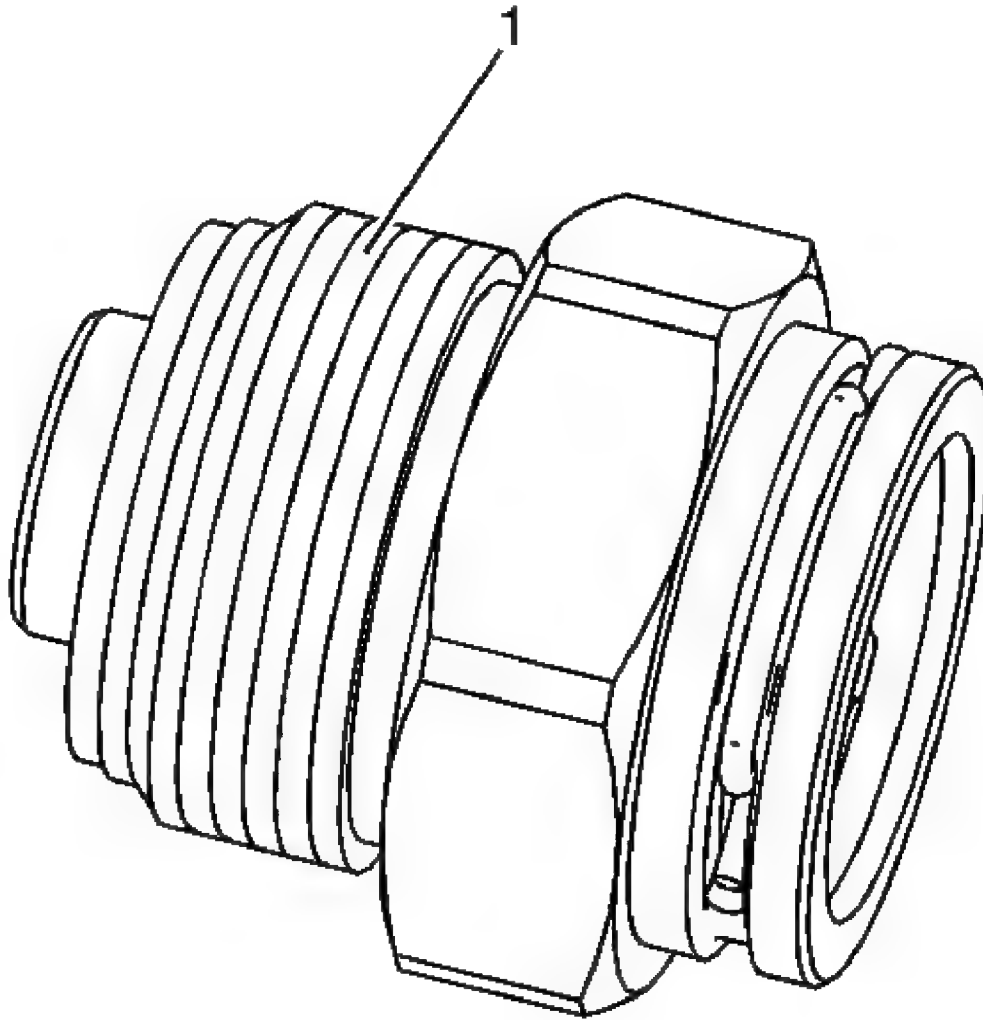


Fig. 104: Identifying Oil Filter Adapter Pipe Fitting
Courtesy of GENERAL MOTORS CORP.

1. Apply threadlocker GM P/N 89021297 (Canadian P/N 109534880) to the threads (1) of the oil filter adapter pipe fitting.

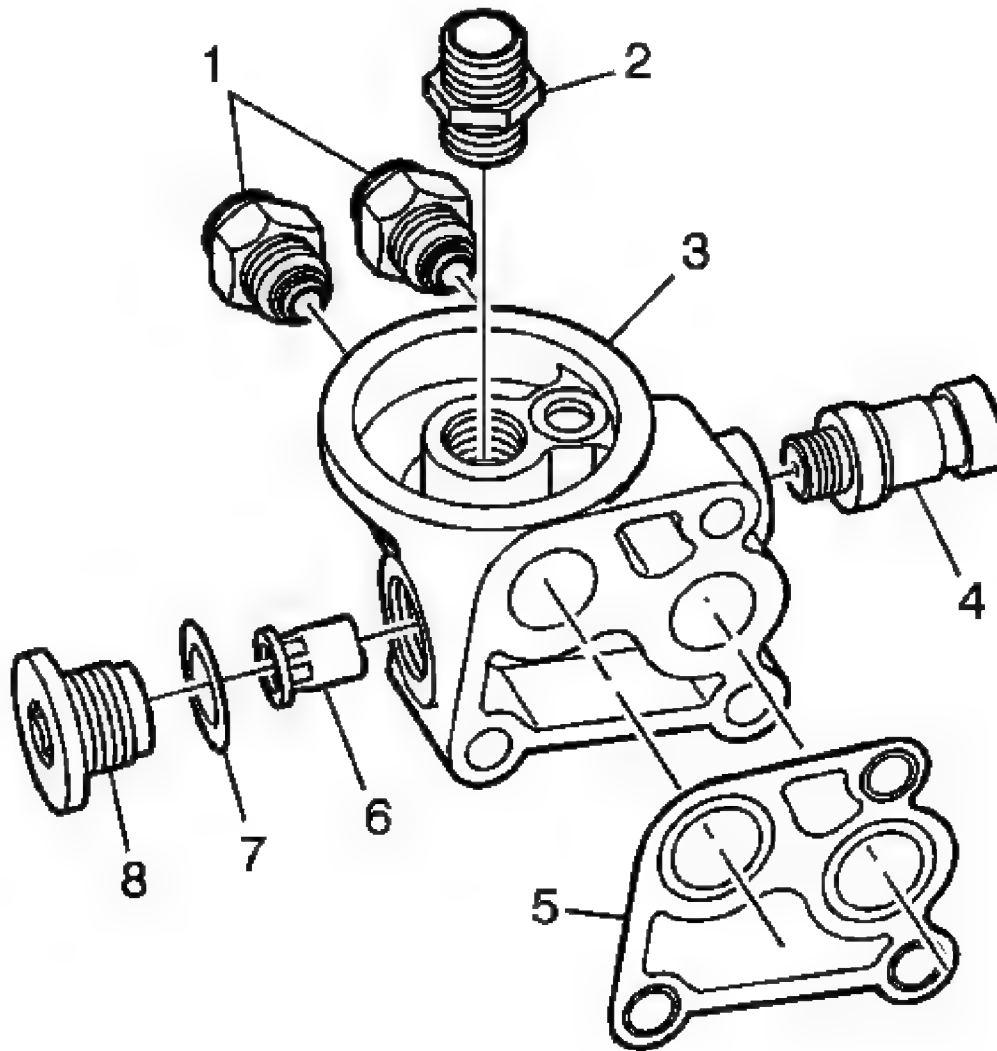


Fig. 105: Identifying Oil Filter Adapter Components (With Oil Cooler)
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

2. Install NEW oil cooler line connector fittings (1).

Tighten: Tighten the oil cooler line connector fittings to 18 N.m (13 lb ft).

3. Install the oil filter fitting (2).

Tighten: Tighten the oil filter fitting to 29 N.m (21 lb ft).

4. Install the oil pressure switch (4).

Tighten: Tighten the oil pressure switch to 16 N.m (12 lb ft).

5. Install the NEW oil filter adapter gasket (5).
6. Install the oil cooler bypass valve (6).
7. Install the NEW oil cooler bypass valve hole plug O-ring (7) onto the oil cooler bypass valve hole plug (8).
8. Install the oil cooler bypass valve hole plug (8).

Tighten: Tighten the oil cooler bypass valve hole plug to 20 N.m (15 lb ft).

OIL PAN CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the oil pan in solvent.

CAUTION: Refer to **SAFETY GLASSES CAUTION.** in Cautions and Notices.

2. Dry the oil pan with compressed air.

INSPECTION PROCEDURE

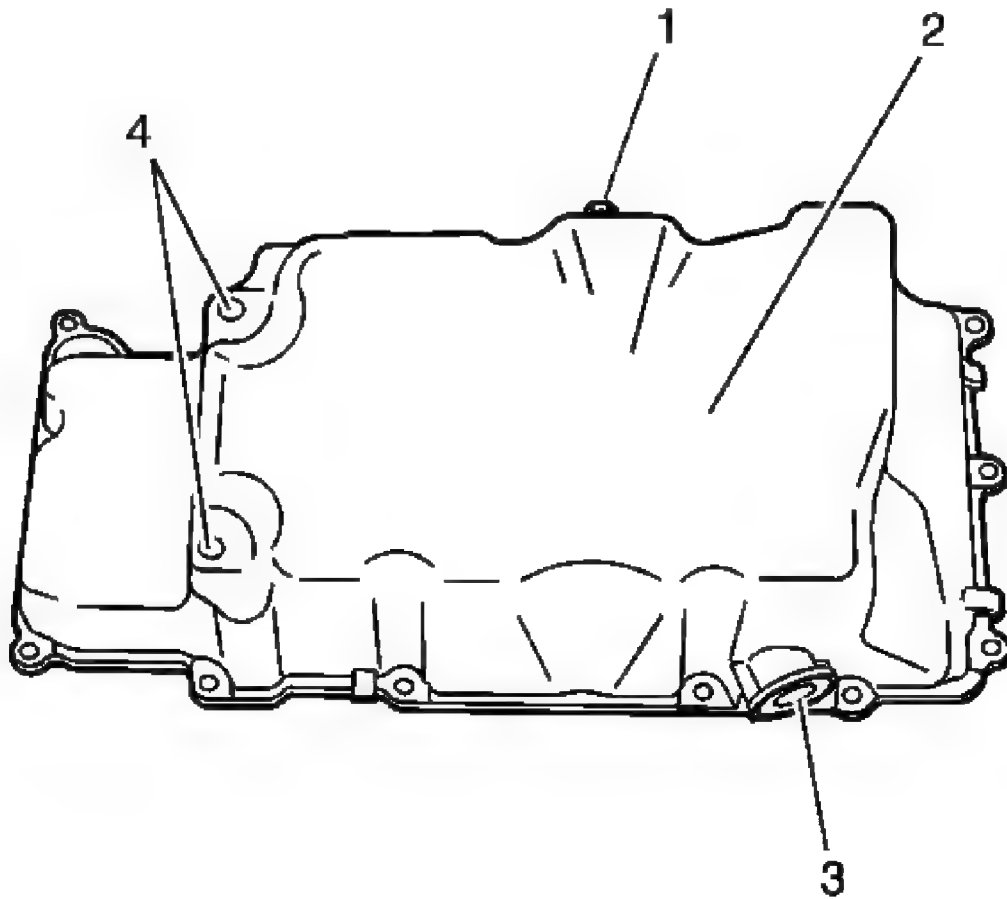


Fig. 106: View of Oil Pan Exterior
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the oil pan for the following conditions:
 - The drain plug hole for damaged threads (1)
 - Damage to the engine mount bracket mounting holes (4)
 - The oil level switch (3) hole for damaged threads
 - Dents or damage to the exterior of the oil pan (2)

An oil pan that is dented may interfere with the position of the oil pump screen or not distribute oil properly in the pan sump area.

- Damage to the oil pan gasket

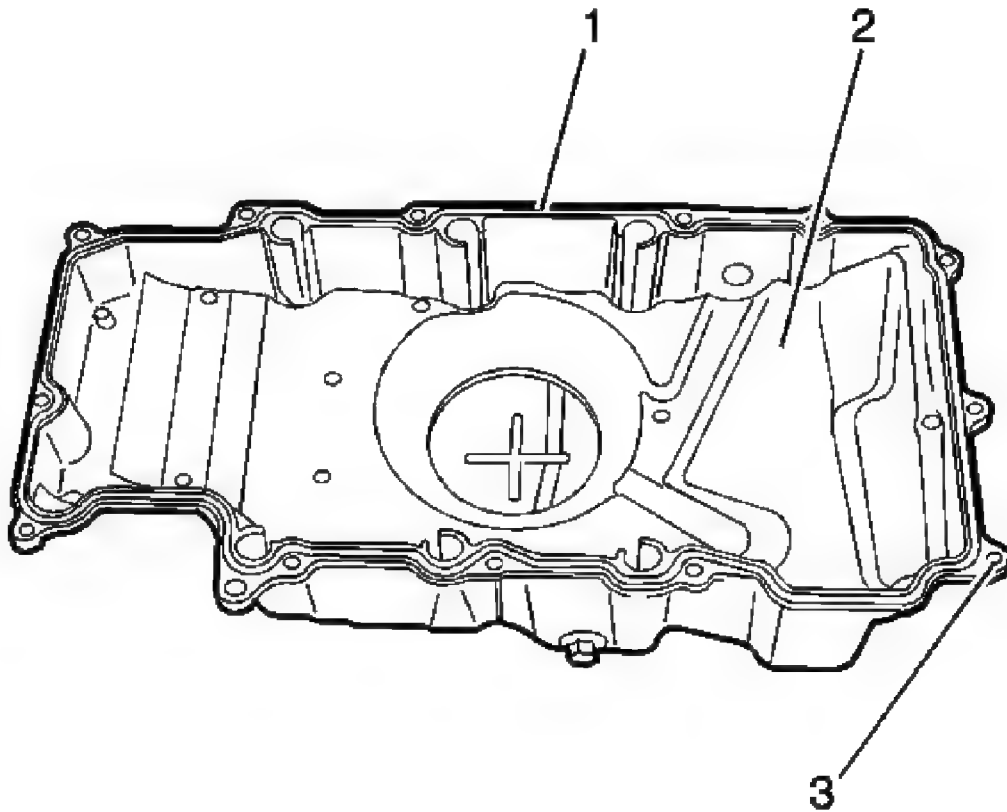


Fig. 107: View of Oil Pan Interior
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the oil pan for the following conditions:
 - Gouges or damage to the oil pan sealing surfaces (1)
 - Damage to the oil pan baffle (2)
 - Damage to the oil pan bolt holes (3)
3. Repair or replace the oil pan as necessary.

CAMSHAFT COVER DISASSEMBLE

DISASSEMBLY PROCEDURE

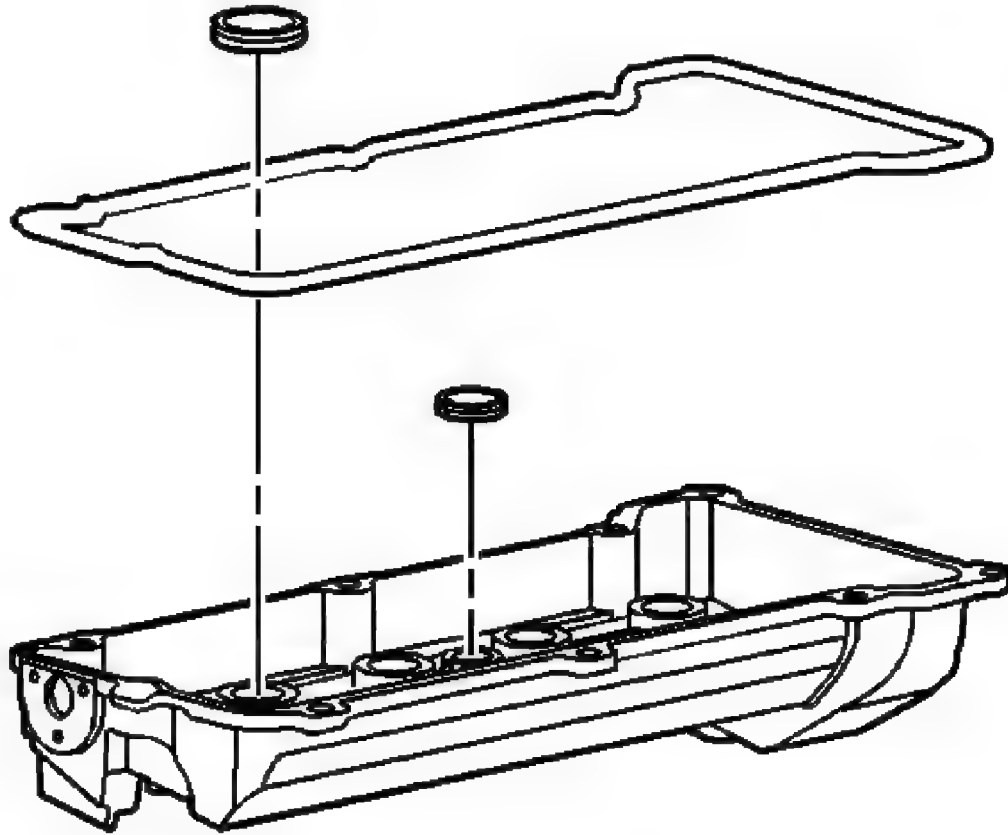


Fig. 108: Identifying Left Camshaft Cover Gasket & Seals
Courtesy of GENERAL MOTORS CORP.

1. Remove the left camshaft cover gasket and discard.
2. Remove the left spark plug port seals and discard.
3. Remove the left ignition module ground/RFI spring port seal and discard.

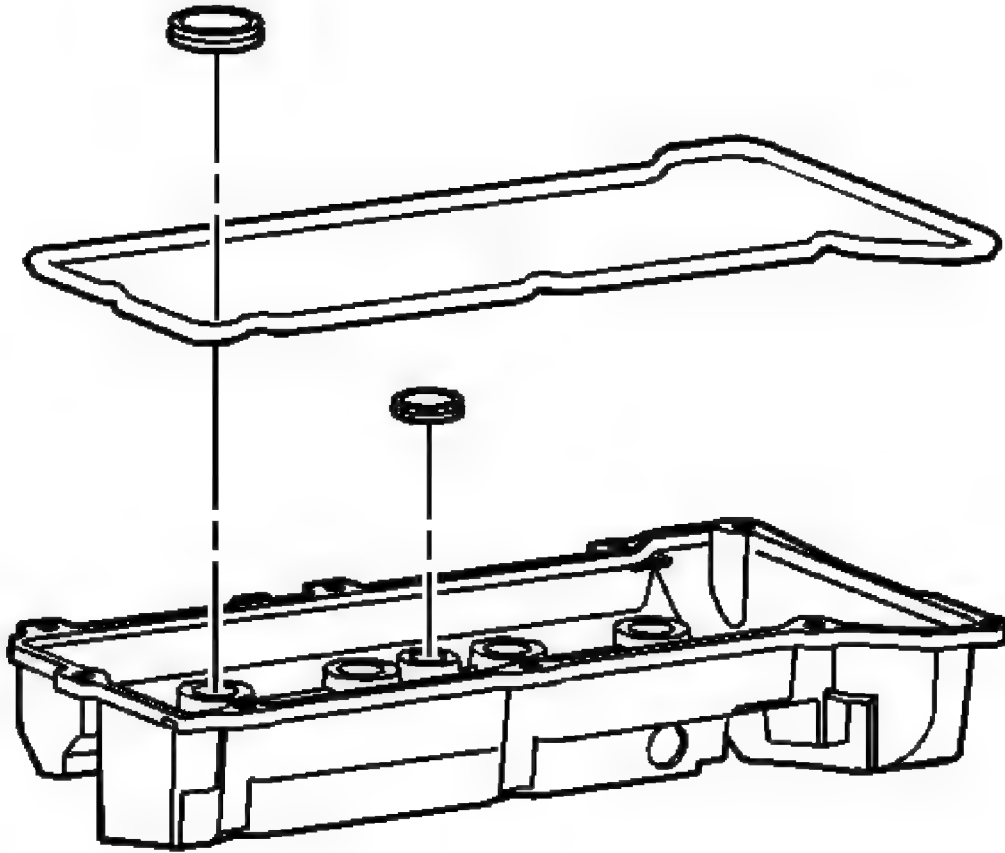


Fig. 109: Identifying Right Camshaft Cover Gasket & Seals
Courtesy of GENERAL MOTORS CORP.

4. Remove the right camshaft cover gasket and discard.
5. Remove the right spark plug port seals and discard.
6. Remove the right ignition module ground/RFI spring port seal and discard.

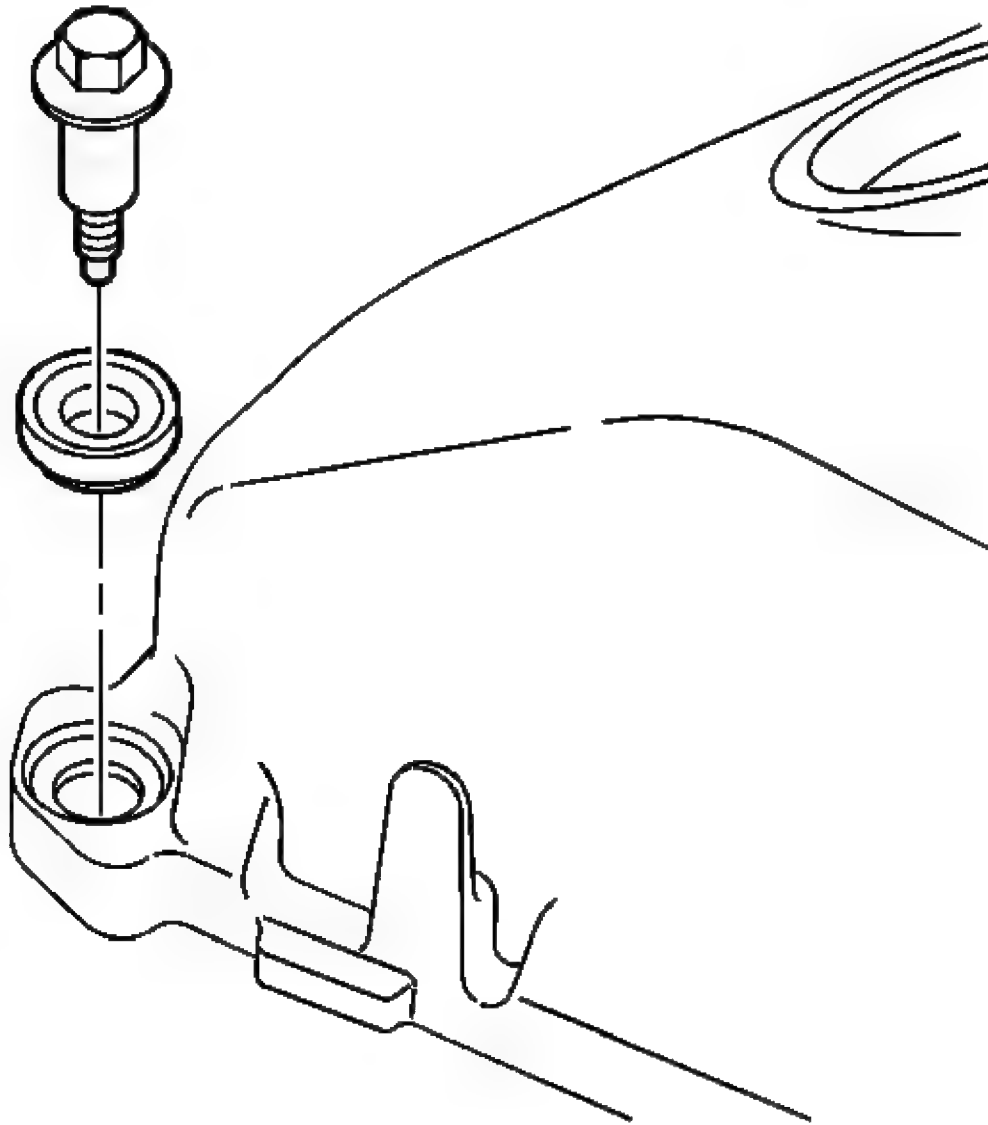


Fig. 110: View Of Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshaft cover bolts.
8. Remove the camshaft cover bolt grommets.

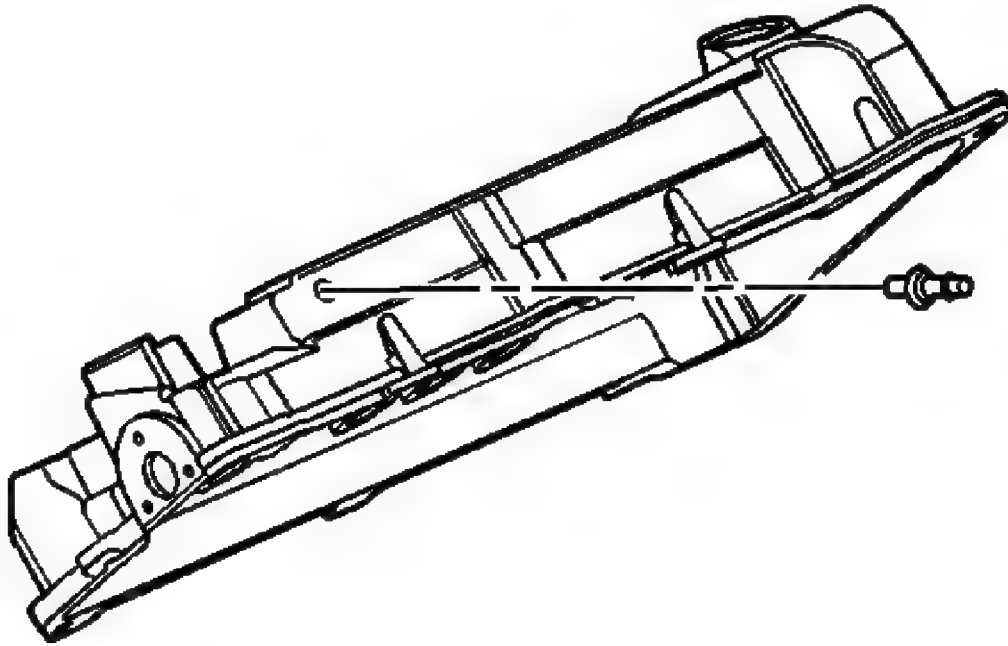


Fig. 111: Separating Right Camshaft from Fresh Air Hose Fitting
Courtesy of GENERAL MOTORS CORP.

9. Remove from the right camshaft cover the fresh air hose fitting.

CAMSHAFT COVER CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the camshaft cover in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the camshaft cover with compressed air.

INSPECTION PROCEDURE

1. Inspect the camshaft cover for the following:
 - Dent or damage to the exterior of the camshaft cover

A dented or damaged cover may:

- Leak oil
- Effect crankcase ventilation
- Interfere with the camshafts
- Interfere with the ignition module sealing
- Allow water or condensation to enter the engine
- Damaged camshaft cover bolts
- Damage or cracking to the camshaft cover bolt grommets
- Restrictions to the ventilation system passages
- Damaged, loose or missing baffle
- Damaged, loose or missing baffle fasteners
- Damage to the oil fill hole in the left camshaft cover
- Damage or cracking to the PCV grommet in the left camshaft cover
- Damage to the ventilation hose nipple in the right camshaft cover
- Damaged threaded holes for the following:
 - Baffle
 - Ignition module
 - Wiring harness retainer
 - Fuel injector sight shield bracket in the right camshaft cover
- Damage or warped seal groove for the following:
 - Camshaft cover seal
 - Spark plug port seals
 - Ignition module ground/RFI spring port seal

2. Repair or replace the camshaft cover as necessary.

CAMSHAFT COVER ASSEMBLE

ASSEMBLY PROCEDURE

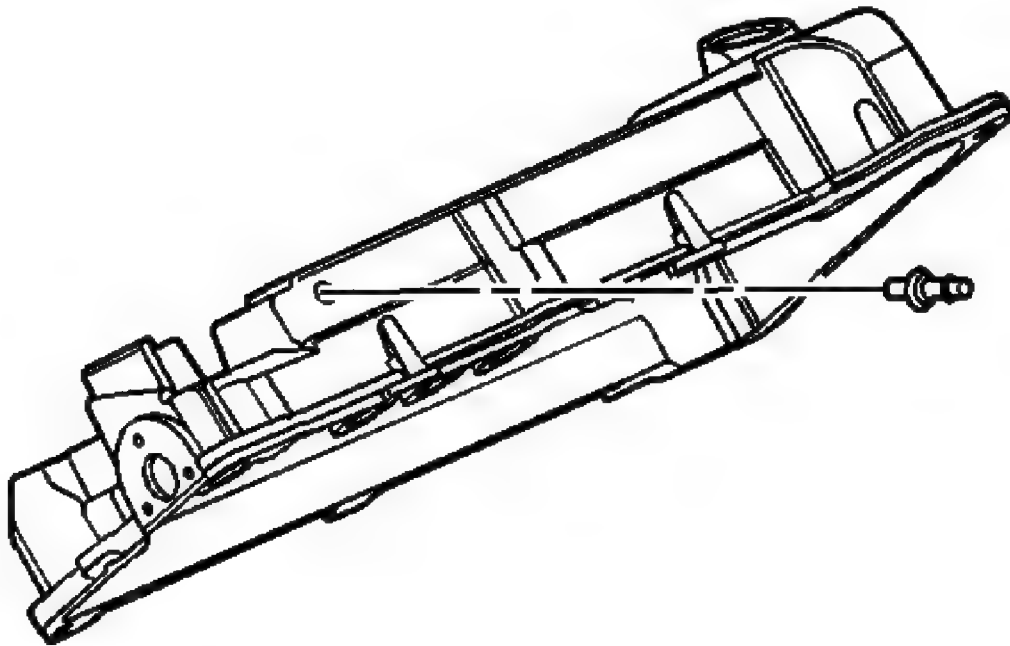


Fig. 112: View Of Fresh Air Hose Fitting & Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

1. Install into the right camshaft cover the fresh air hose fitting.

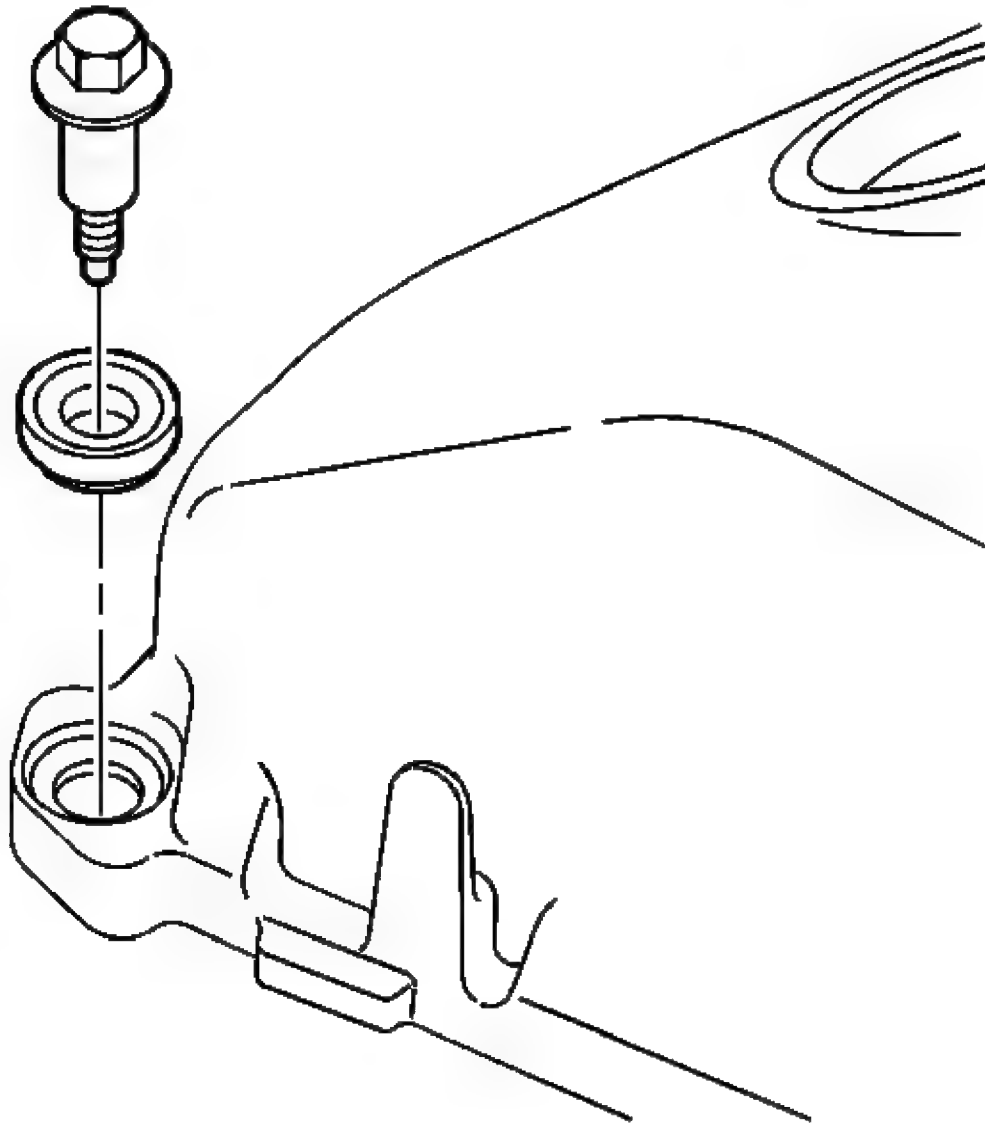


Fig. 113: View Of Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the camshaft cover bolt grommets.
3. Install the camshaft cover bolts.

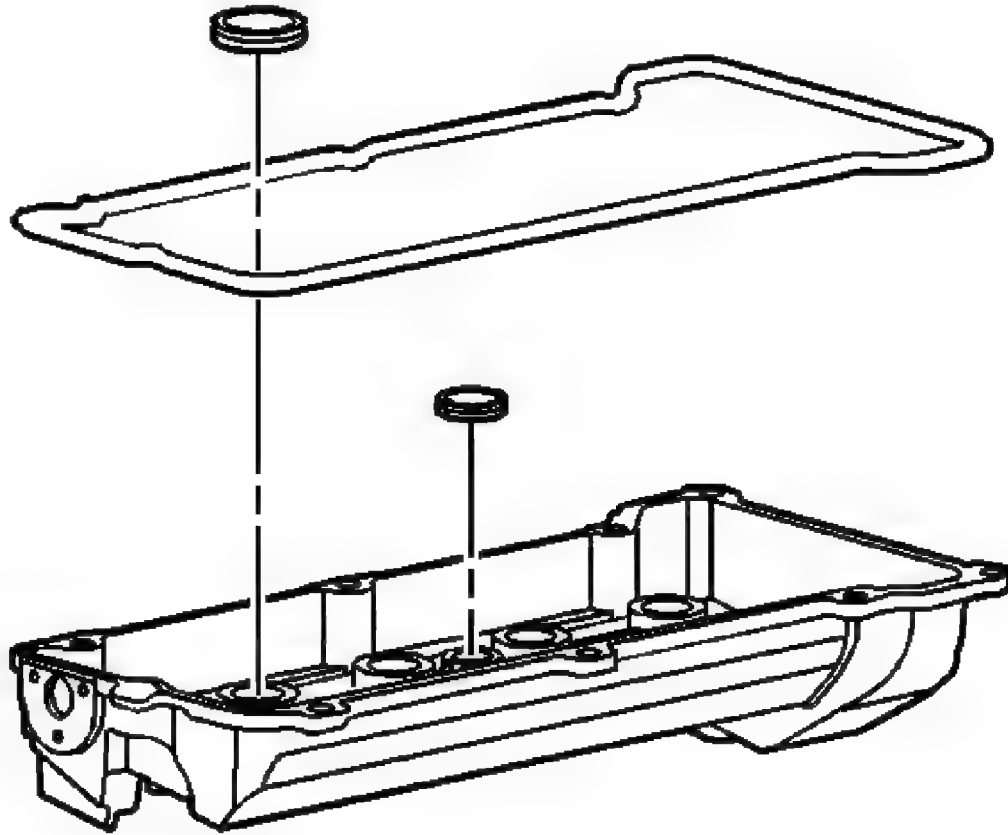


Fig. 114: Identifying Left Camshaft Cover Gasket & Seals
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW left camshaft cover gasket.
5. Install the NEW left spark plug port seals.
6. Install the NEW left ignition module ground/RFI spring port seal.

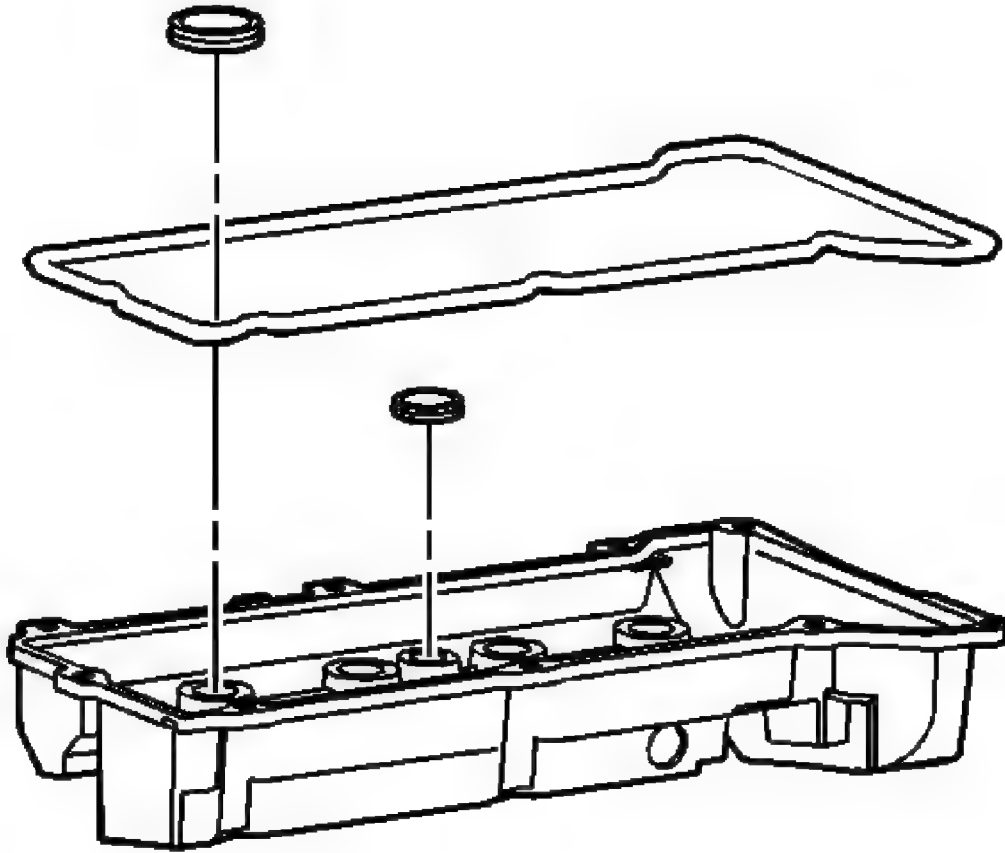


Fig. 115: Identifying Right Camshaft Cover Gasket & Seals
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW right camshaft cover gasket.
8. Install the NEW right spark plug port seals.
9. Install the NEW right ignition module ground/RFI spring port seal.

INTAKE MANIFOLD DISASSEMBLE

DISASSEMBLY PROCEDURE

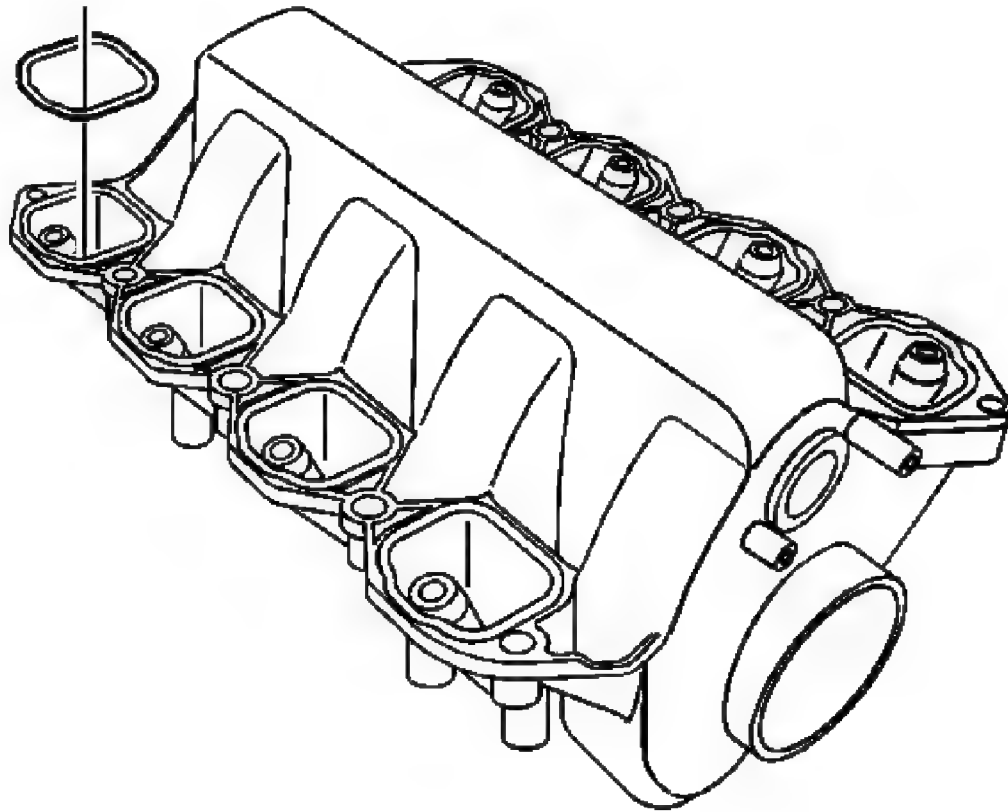


Fig. 116: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the intake manifold-to-cylinder head sealing gaskets.

1. Remove and discard the intake manifold-to-cylinder head gaskets.

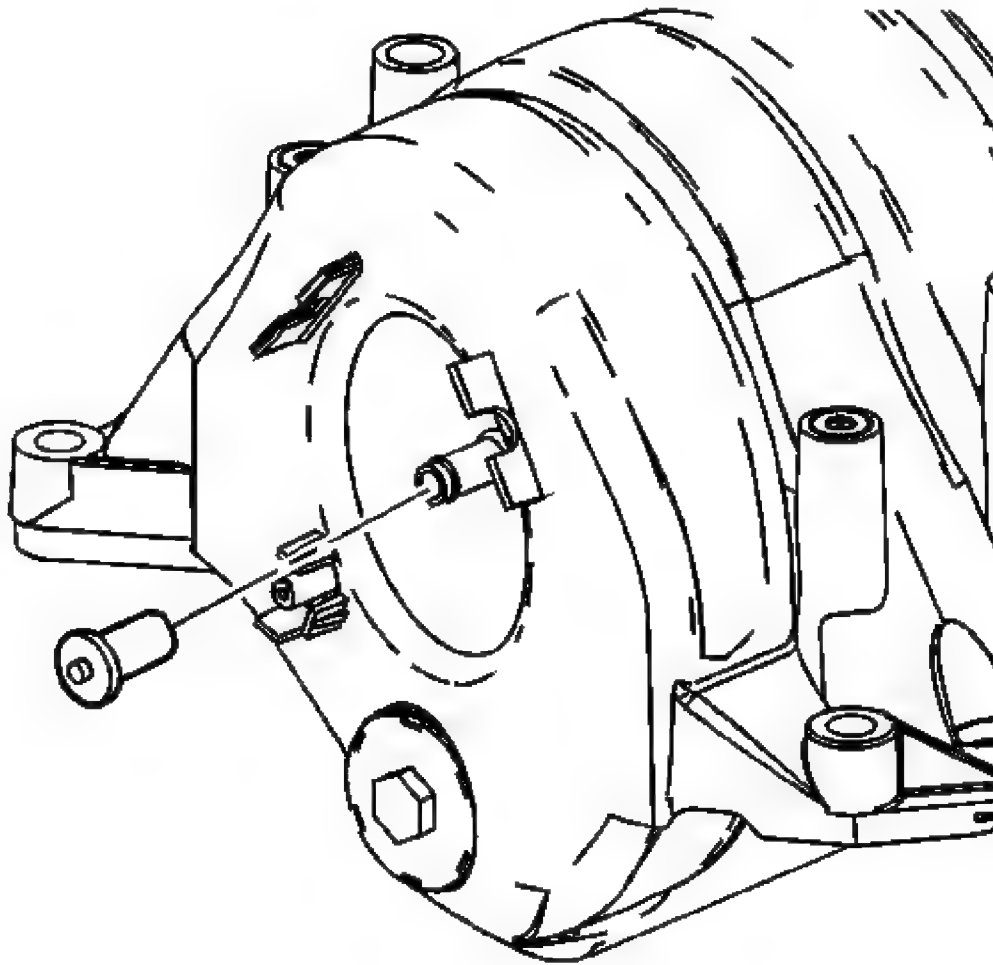


Fig. 117: Identifying Intake Manifold Vacuum Cap
Courtesy of GENERAL MOTORS CORP.

2. Remove the intake manifold vacuum cap.

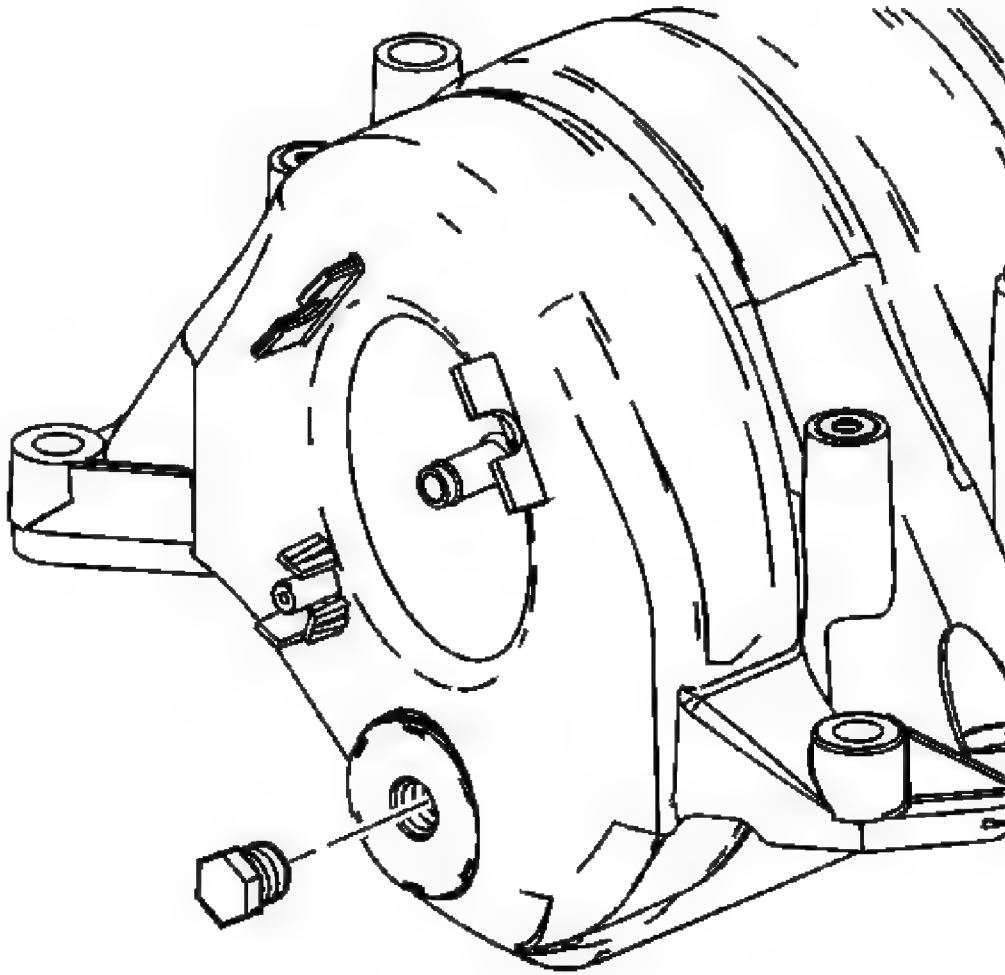


Fig. 118: Identifying Intake Manifold Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the intake manifold plug.

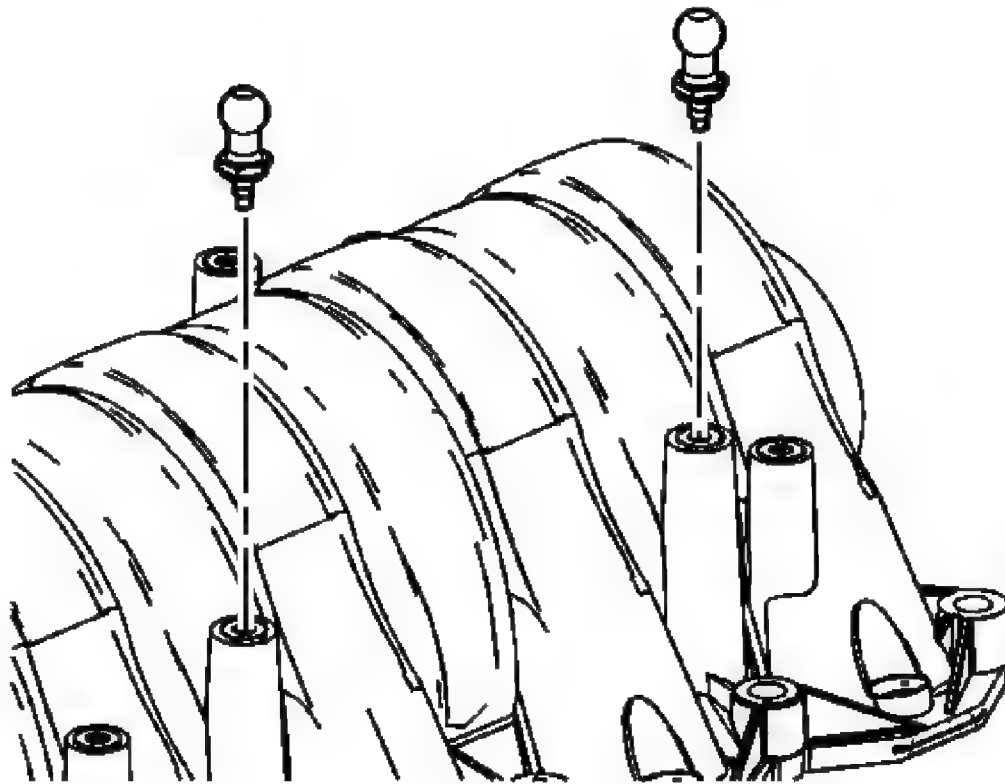


Fig. 119: Identifying Intake Manifold Sight Shield Ball Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold sight shield ball studs.

INTAKE MANIFOLD CLEANING AND INSPECTION

CLEANING PROCEDURE

IMPORTANT: Do not reuse the intake manifold-to-cylinder head sealing gaskets.

1. Remove any remaining gasket and/or gasket material from the intake manifold.
2. Clean the following intake manifold areas in solvent.
 - Intake manifold gasket grooves
 - Intake manifold passages
 - PCV vacuum hose passage

- Vacuum hose fitting passage

CAUTION: Refer to Safety Glasses Caution .

3. Dry the intake manifold with compressed air.

INSPECTION PROCEDURE

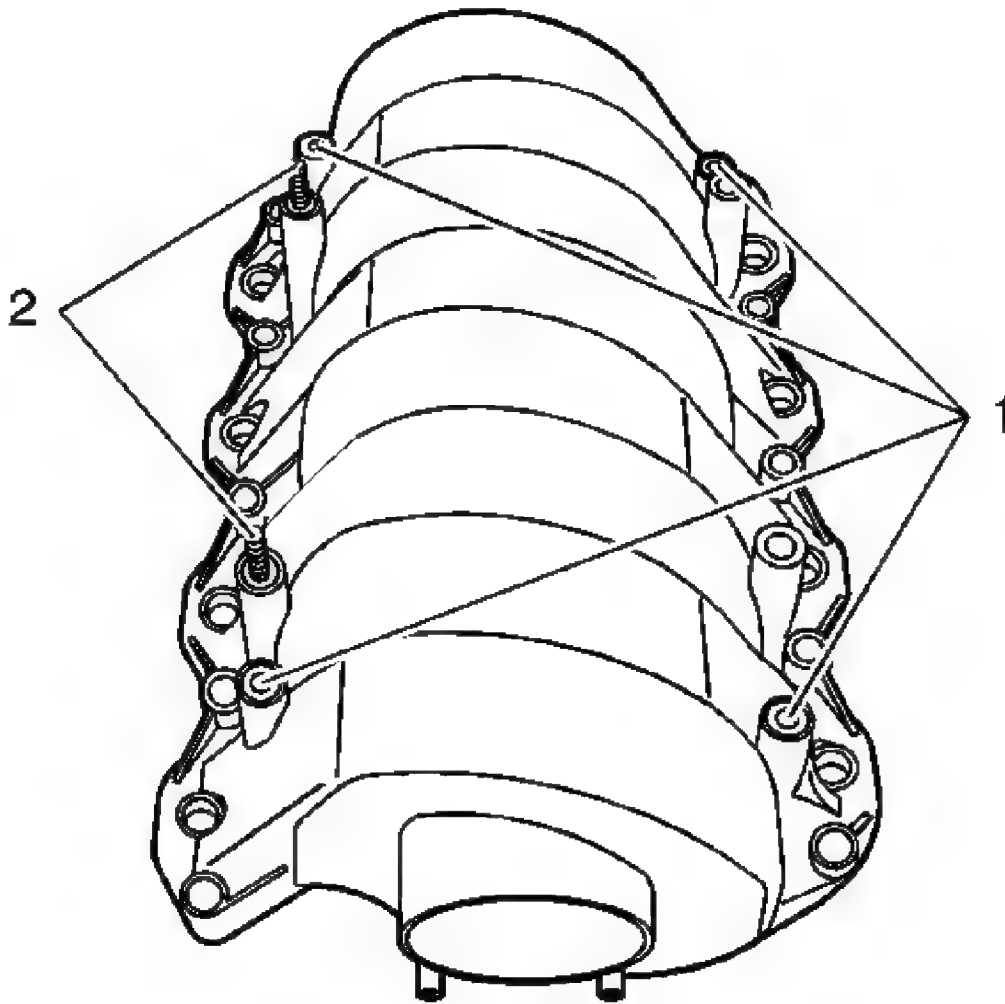


Fig. 120: View Of Inspection Areas Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the intake manifold for the following conditions:

- Damage to the fuel rail mounting inserts (1)
- Damage to the studs (2)

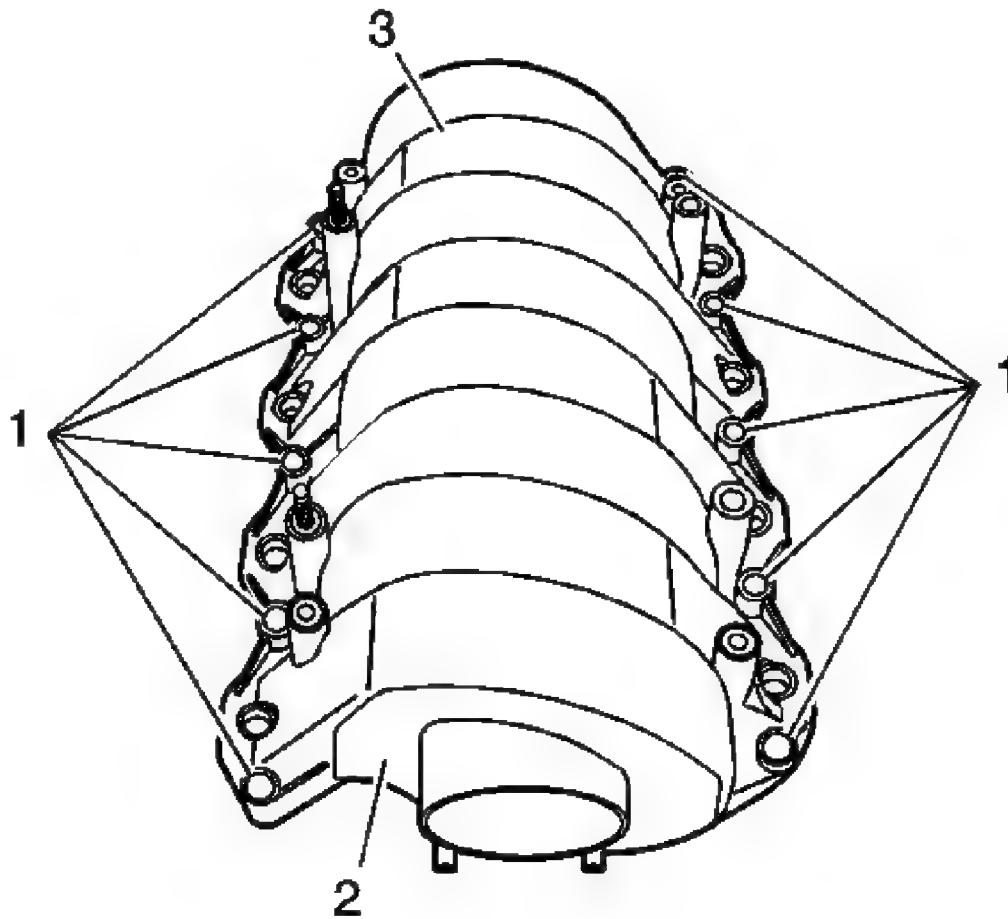


Fig. 121: View Of Additional Inspection Areas Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Inspect the intake manifold for the following conditions:
 - Damage to the intake manifold bolt bosses (1)
 - Damage or cracks to the composite intake manifold assembly (2)
 - Damage in areas between the intake runners (3)

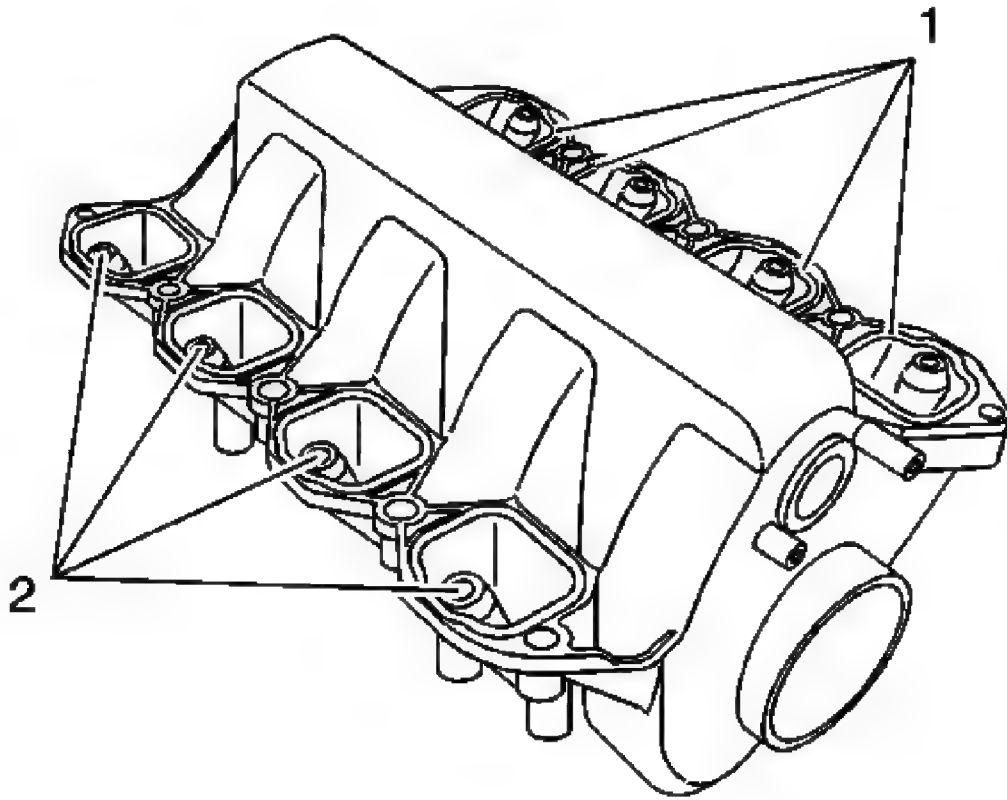


Fig. 122: Inspecting Intake Manifold For Damage To Sealing Surfaces & Fuel Injector Bores

Courtesy of GENERAL MOTORS CORP.

3. Inspect the intake manifold for the following conditions:
 - Damage, gouges or cracks to the intake manifold sealing surfaces and grooves (1)
 - Damage or excessive scoring to the fuel injector bores (2)

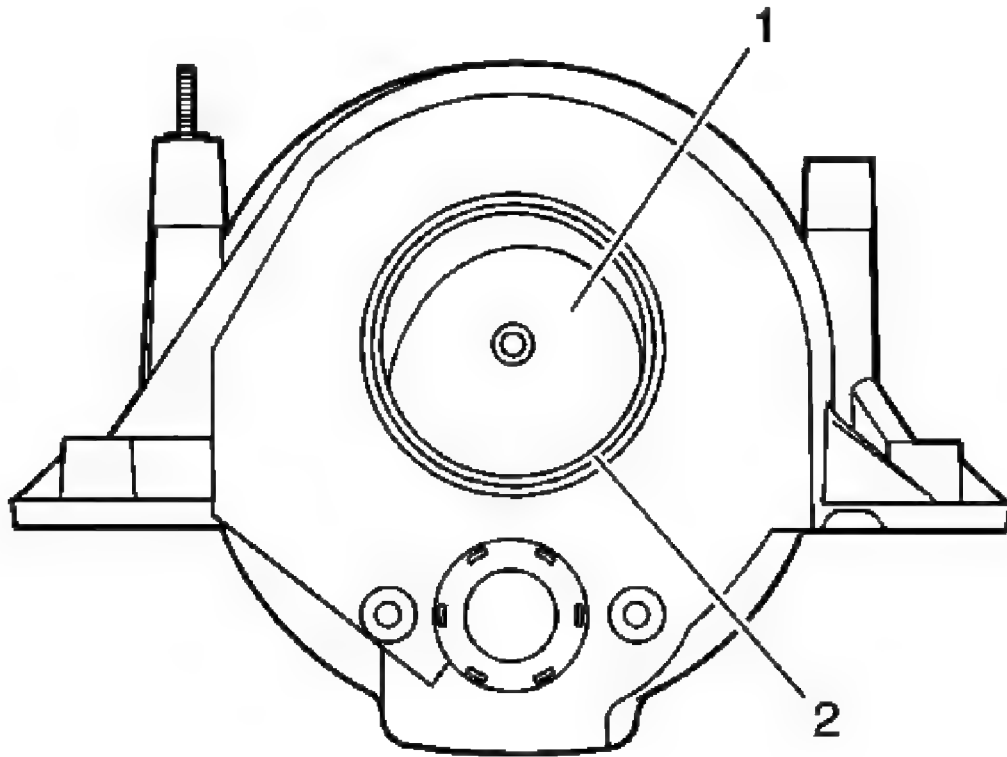


Fig. 123: Inspecting Front Intake Manifold For Damage To Passage & Plenum Duct Neck

Courtesy of GENERAL MOTORS CORP.

4. Inspect the front of the intake manifold for the following conditions:
 - Damage, debris or restrictions to the intake manifold passage (1)
 - Damage to the plenum duct neck (2)

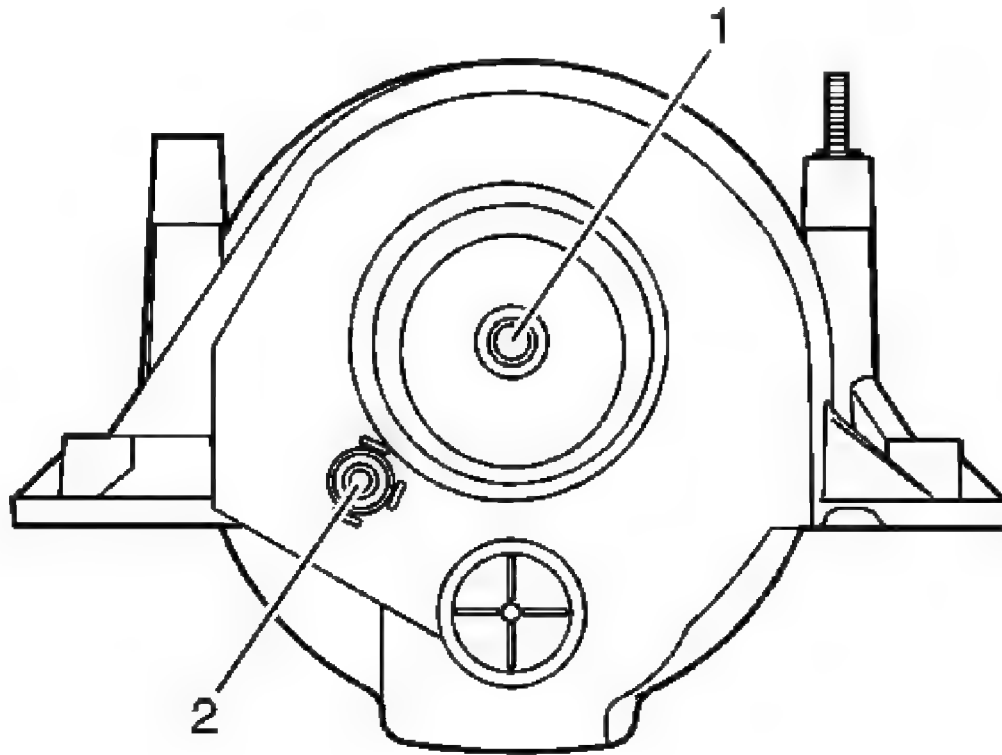


Fig. 124: Inspecting Intake Manifold For Damage To PCV System Hose & Vacuum Ports

Courtesy of GENERAL MOTORS CORP.

5. Inspect the intake manifold for the following conditions:
 - Damage, debris or restrictions to the PCV system hose port (1)
 - Damage, debris or restrictions to the vacuum port (2)
6. Inspect the intake manifold cylinder head deck for warpage.
 1. Locate a straight edge across the intake manifold cylinder head deck surface.
 2. Insert a feeler gage between the intake manifold and the straight edge. An intake manifold with warpage in excess of 0.25 mm per 25 mm (0.010 in per 1.00 in) must be replaced.
7. Repair or replace the intake manifold as necessary.

INTAKE MANIFOLD ASSEMBLE

ASSEMBLY PROCEDURE

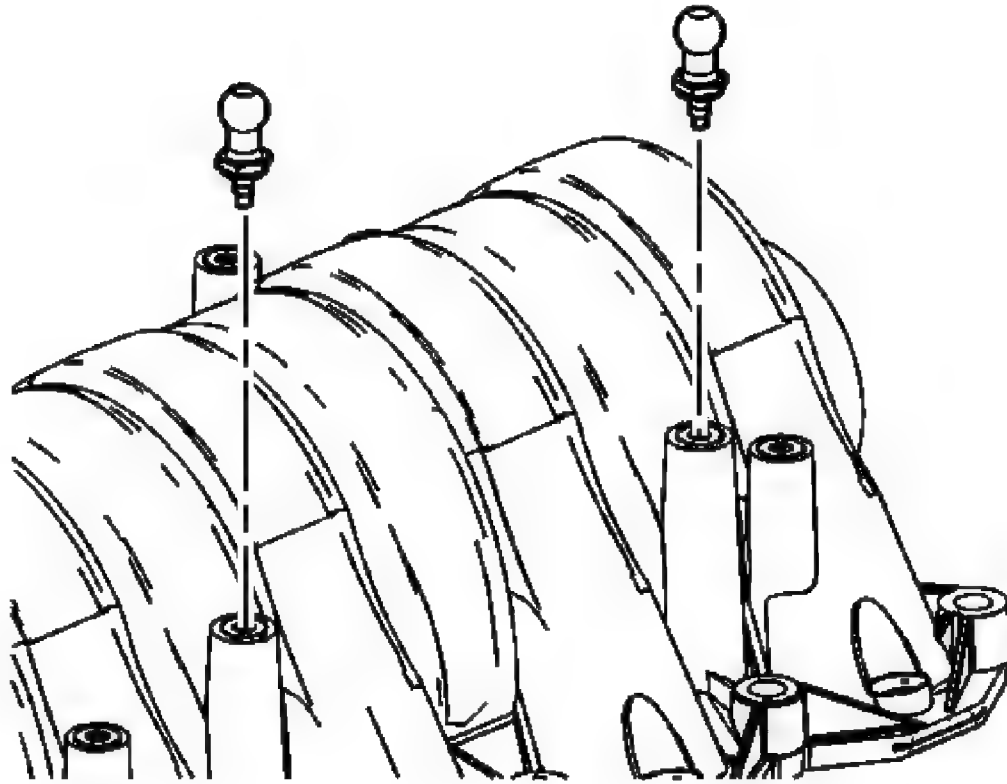


Fig. 125: Identifying Intake Manifold Sight Shield Ball Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the intake manifold sight shield ball studs.

Tighten: Tighten the intake manifold ball studs to 7 N.m (62 lb in).

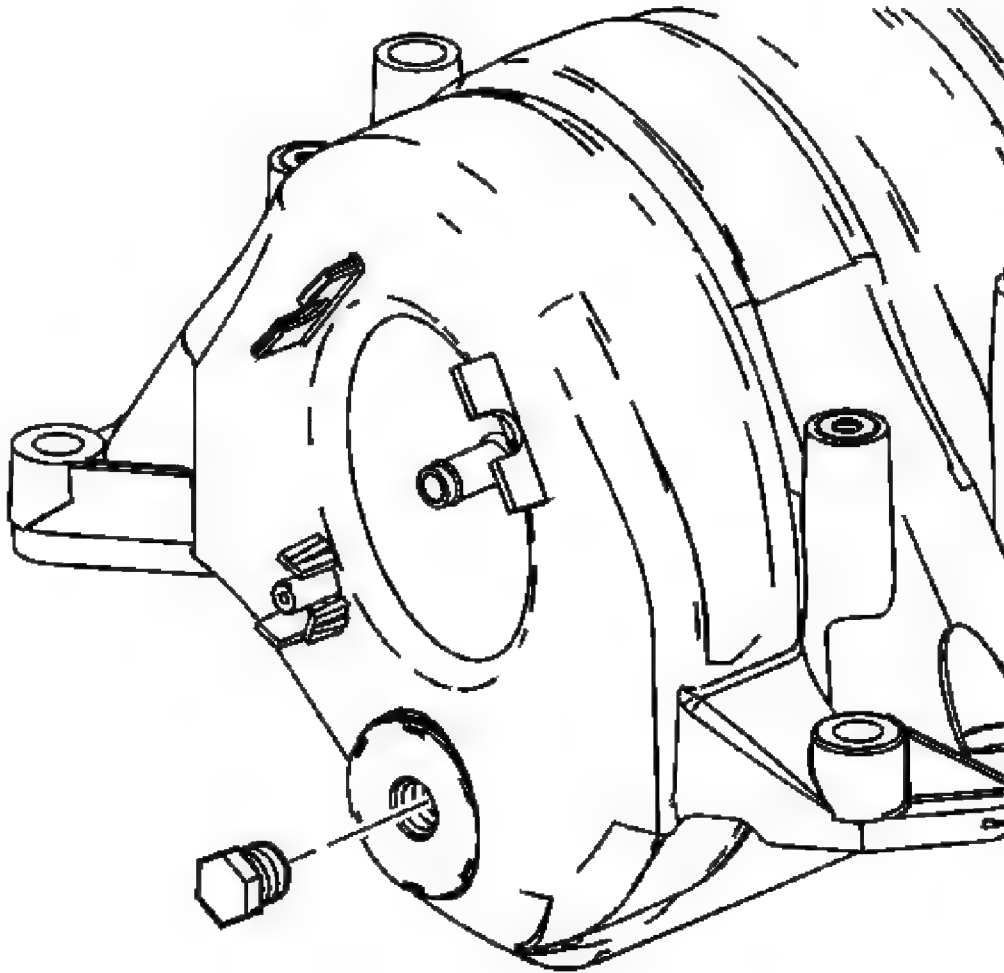


Fig. 126: Identifying Intake Manifold Plug
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold plug.

Tighten: Tighten the intake manifold plug to 2 N.m (18 lb in).

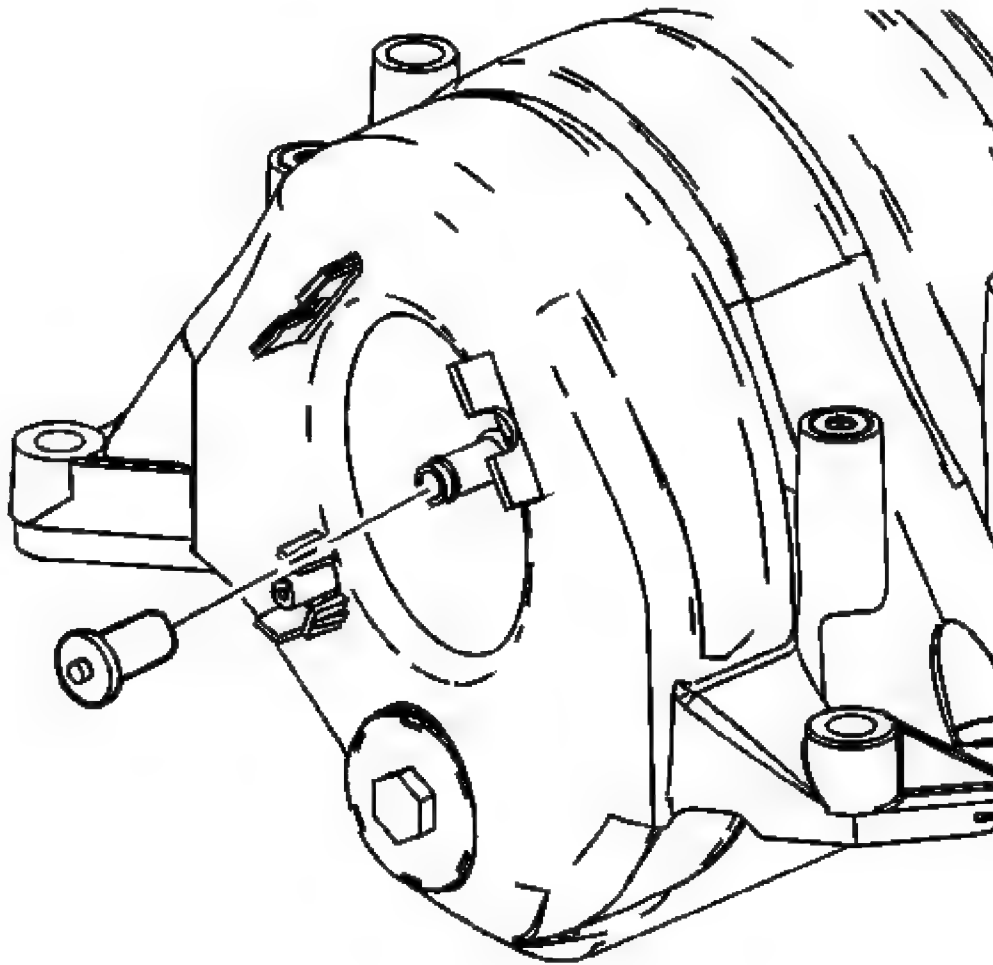


Fig. 127: Identifying Intake Manifold Vacuum Cap
Courtesy of GENERAL MOTORS CORP.

3. Install the vacuum cap.

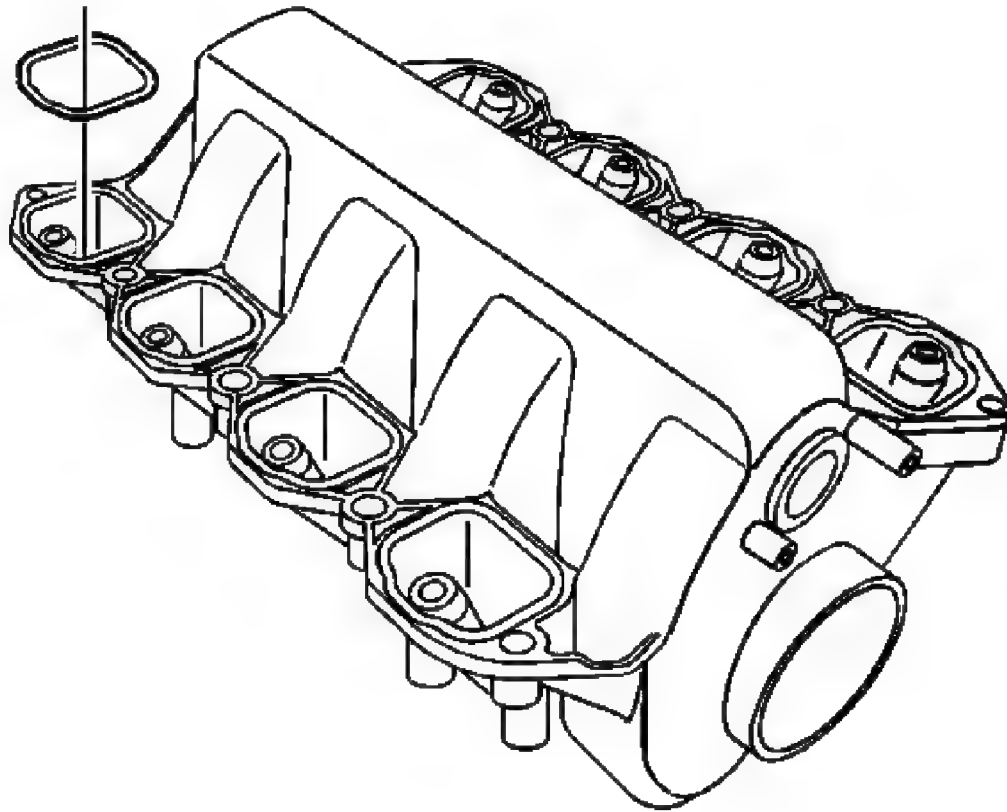


Fig. 128: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the intake manifold-to-cylinder head sealing gaskets.

4. Install NEW intake manifold-to-cylinder head gaskets.

EXHAUST MANIFOLD CLEANING AND INSPECTION - LEFT SIDE

CLEANING PROCEDURE

1. Clean the exhaust manifold in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION. .

2. Dry the exhaust manifold with compressed air.

INSPECTION PROCEDURE

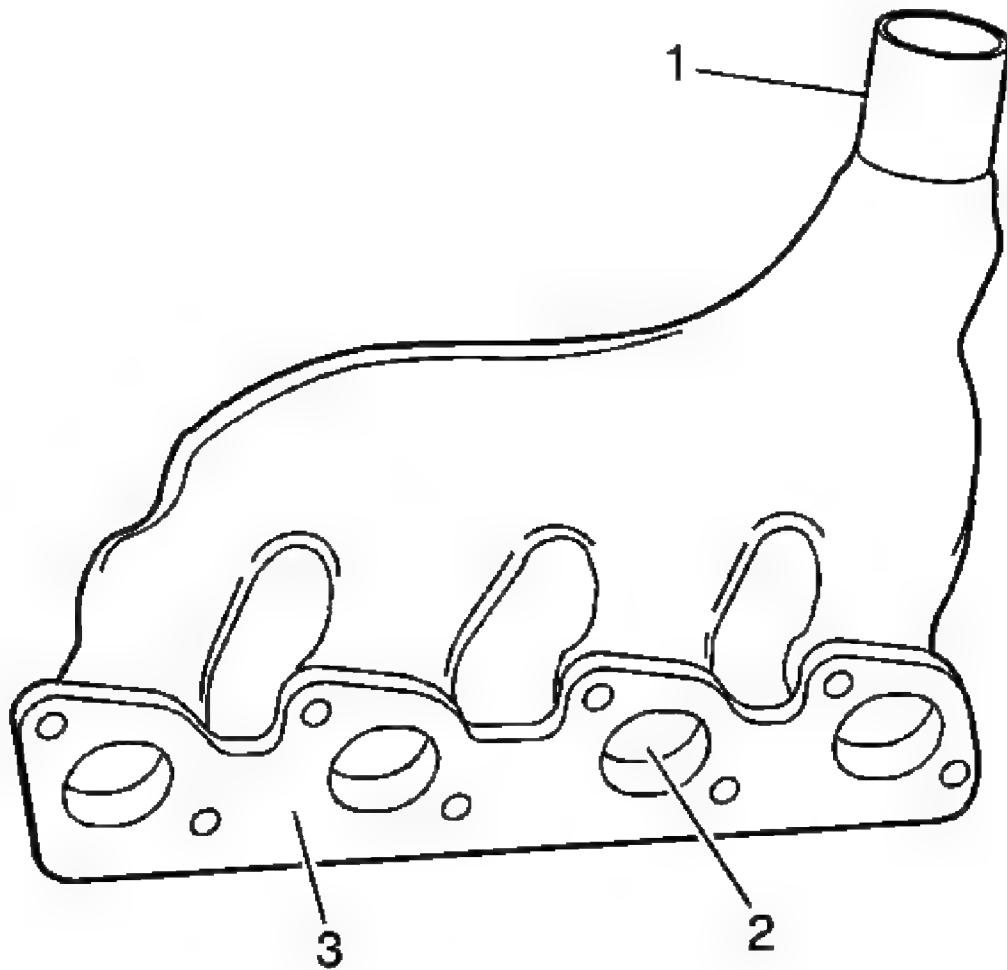


Fig. 129: View Of Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exhaust manifold for the following:
 - Damage to the exhaust crossover sealing area (1)
 - Damage or restrictions within the exhaust passages (2)
 - Damage to the gasket sealing surfaces (3)

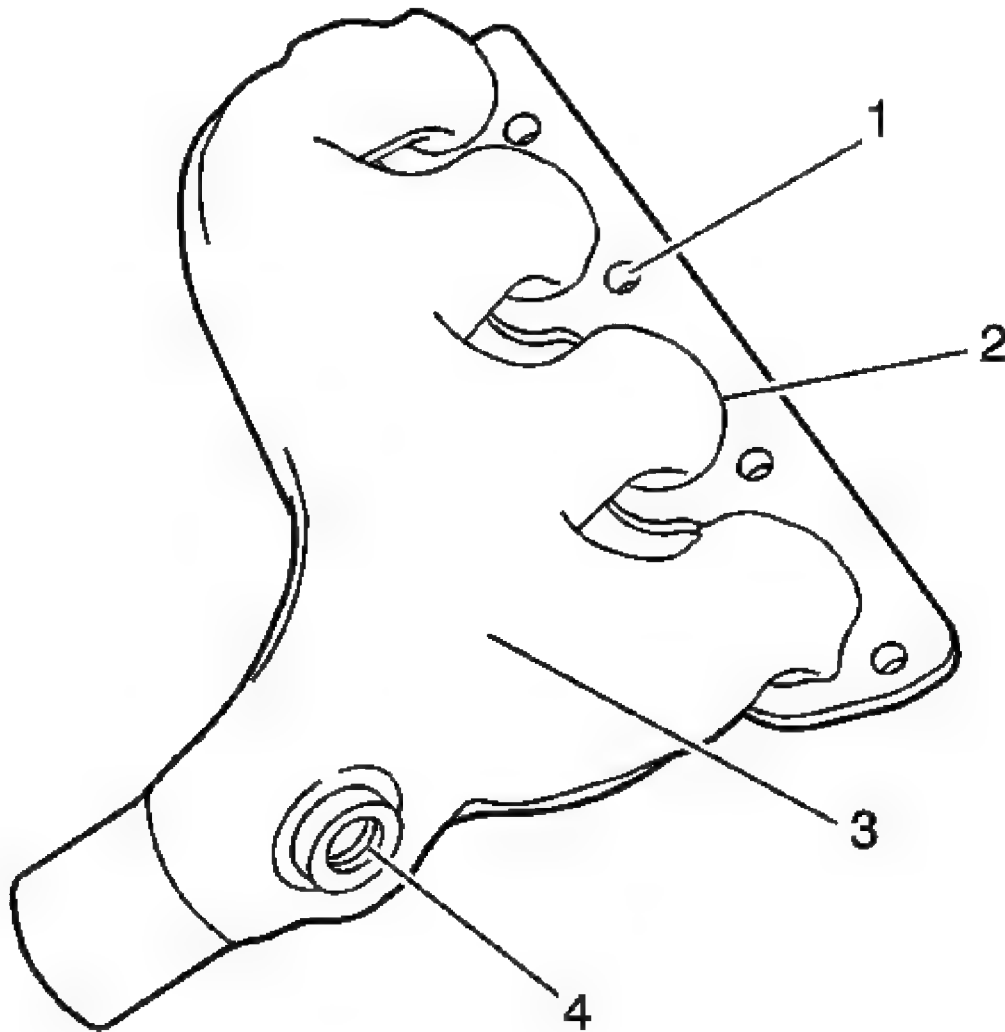


Fig. 130: Inspecting Left Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

2. Inspect the exhaust manifold for the following:
 - Damage to the exhaust manifold mounting holes (1)
 - Damage or broken welds (2)
 - Damage or excessive corrosion to the exhaust manifold exterior (3)
 - Damage to the oxygen sensor threaded hole (4)
3. Repair or replace the exhaust manifold and/or components as necessary.

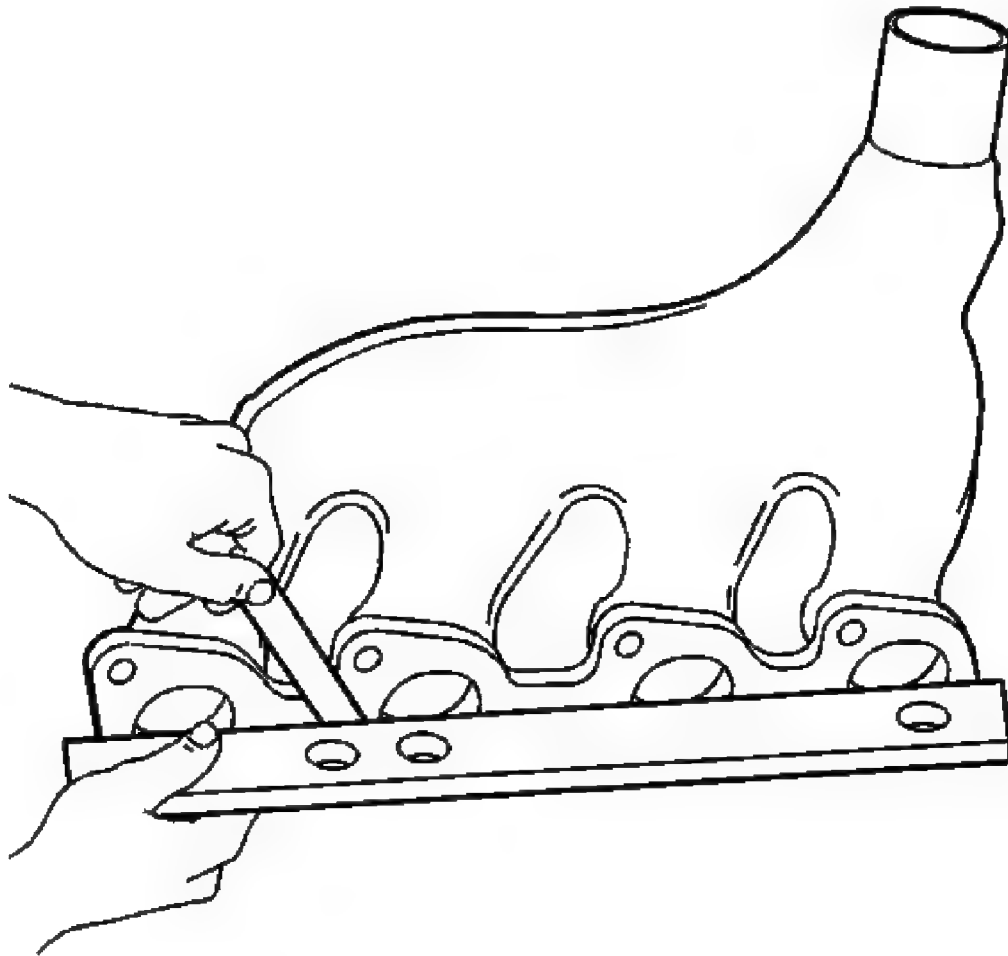


Fig. 131: Measuring Surface Flatness Of Left Exhaust Manifold Flanges
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gage. Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.

EXHAUST MANIFOLD CLEANING AND INSPECTION - RIGHT SIDE

CLEANING PROCEDURE

1. Clean the exhaust manifold in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the exhaust manifold with compressed air.

INSPECTION PROCEDURE

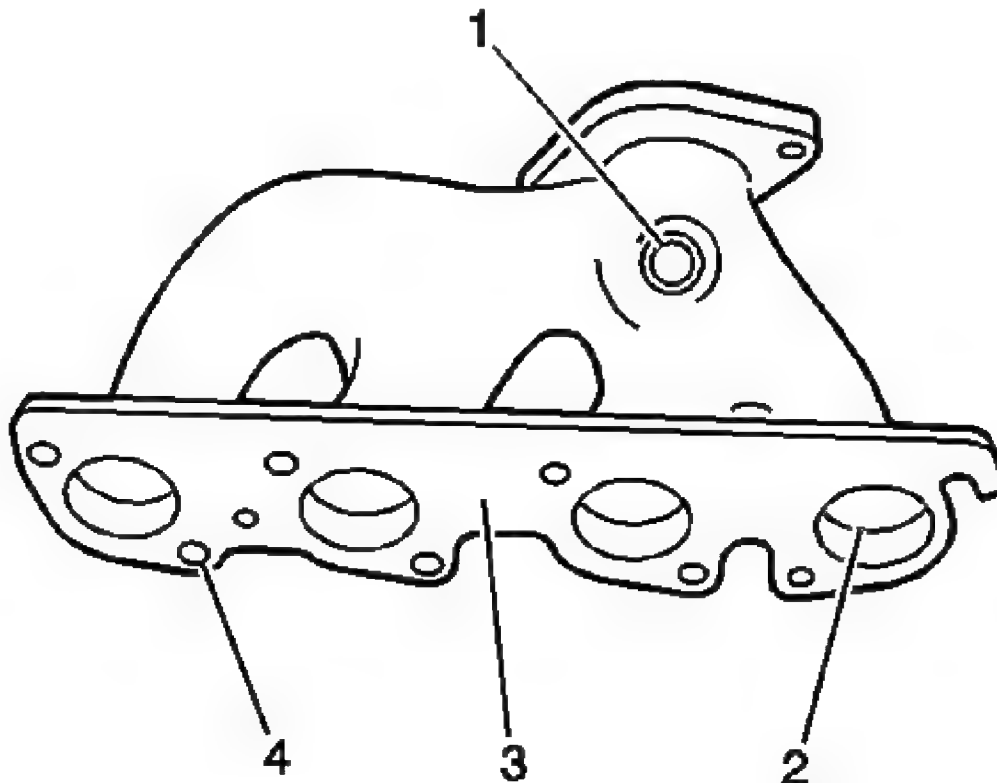


Fig. 132: View Of Inspection Areas Of Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exhaust manifold for the following:
 - Damage to the oxygen sensor threaded hole (1)
 - Damage or restrictions within the exhaust passages (2)
 - Damage to the gasket sealing surfaces (3)
 - Damage to the exhaust manifold mounting holes (4)

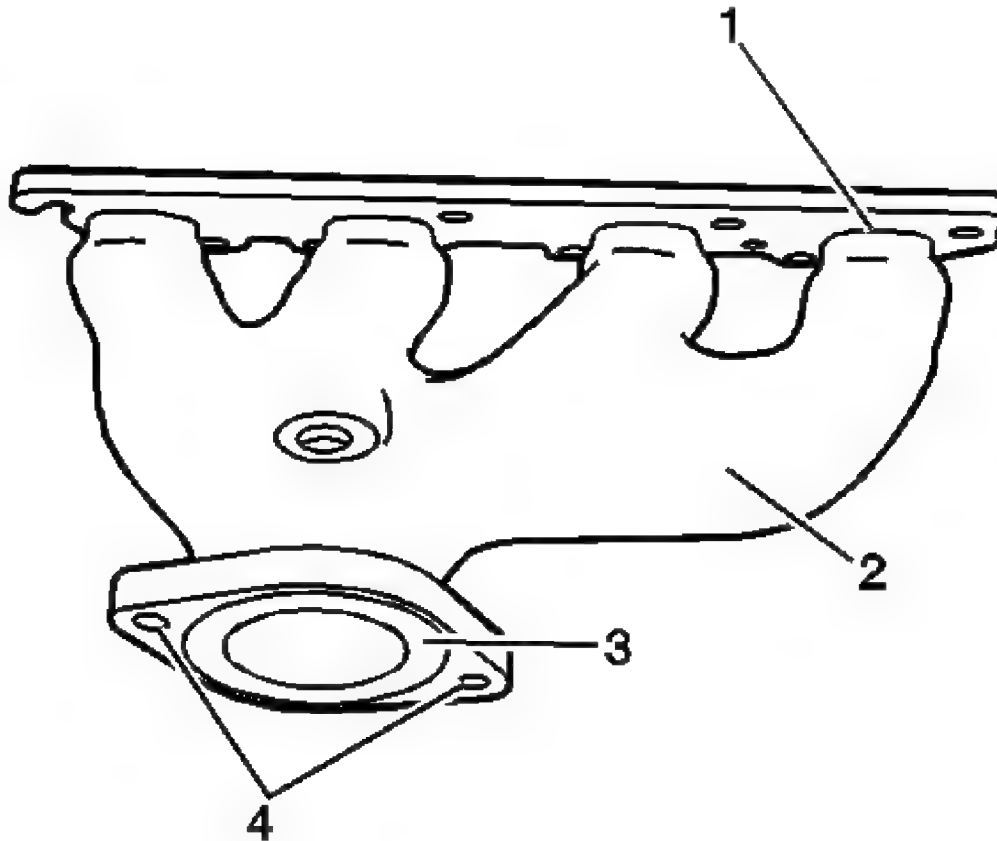


Fig. 133: Inspecting Right Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

2. Inspect the exhaust manifold for the following:
 - Damage or broken welds (1)
 - Damage or excessive corrosion to the exhaust manifold exterior (2)
 - Damage to the converter pipe gasket sealing surfaces (3)
 - Damage to the converter pipe mounting holes (4)
3. Repair or replace the exhaust manifold and/or components as necessary.

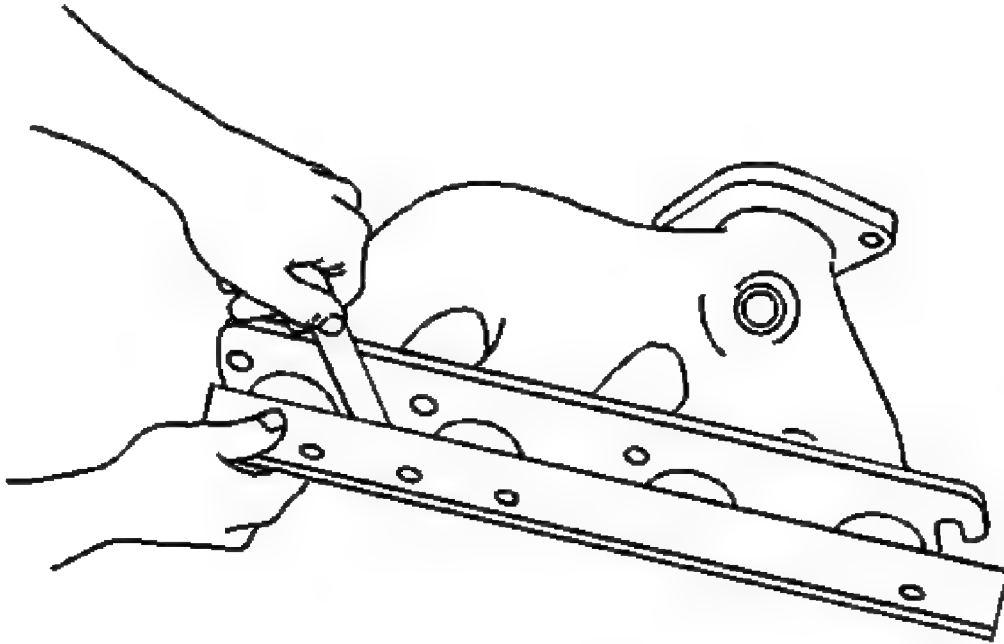


Fig. 134: Measuring Surface Flatness Of Right Exhaust Manifold Flanges
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gage. Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.

WATER CROSSOVER DISASSEMBLE

DISASSEMBLY PROCEDURE

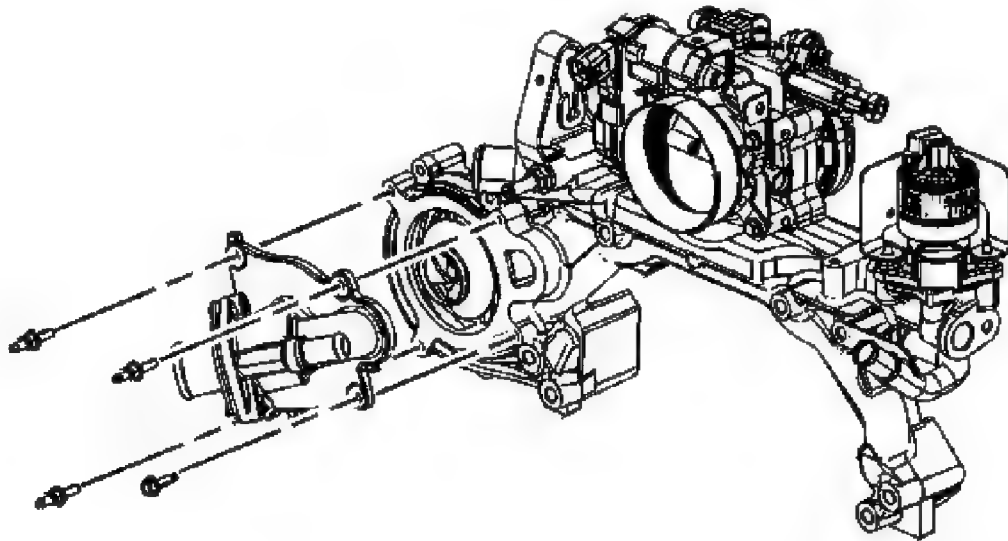


Fig. 135: View Of Water Pump Cover, Bolt & Studs
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump cover bolt and studs.
2. Remove the water pump cover.

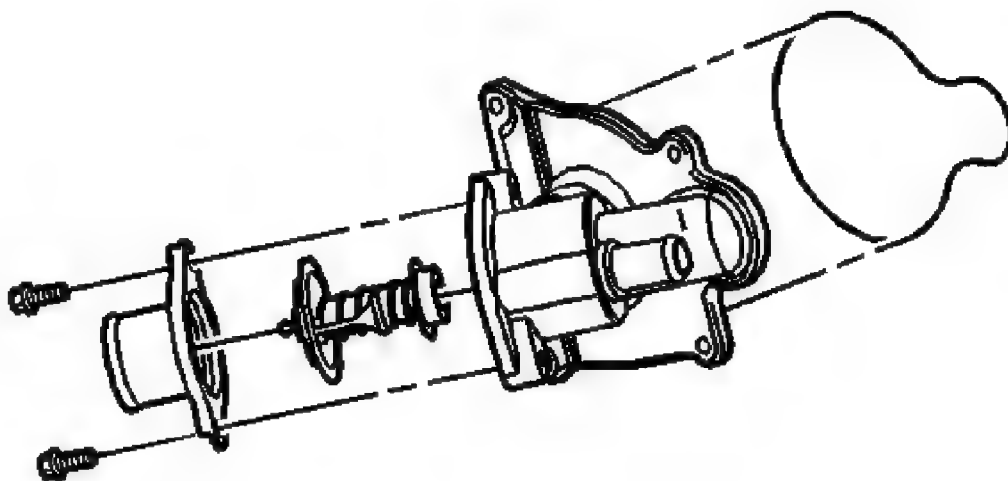


Fig. 136: View Of Water Pump Cover Gasket, Water Outlet, Thermostat & Bolts

Courtesy of GENERAL MOTORS CORP.

3. Remove the water outlet bolts.
4. Remove the water outlet and thermostat.
5. Remove and discard the water pump cover gasket.

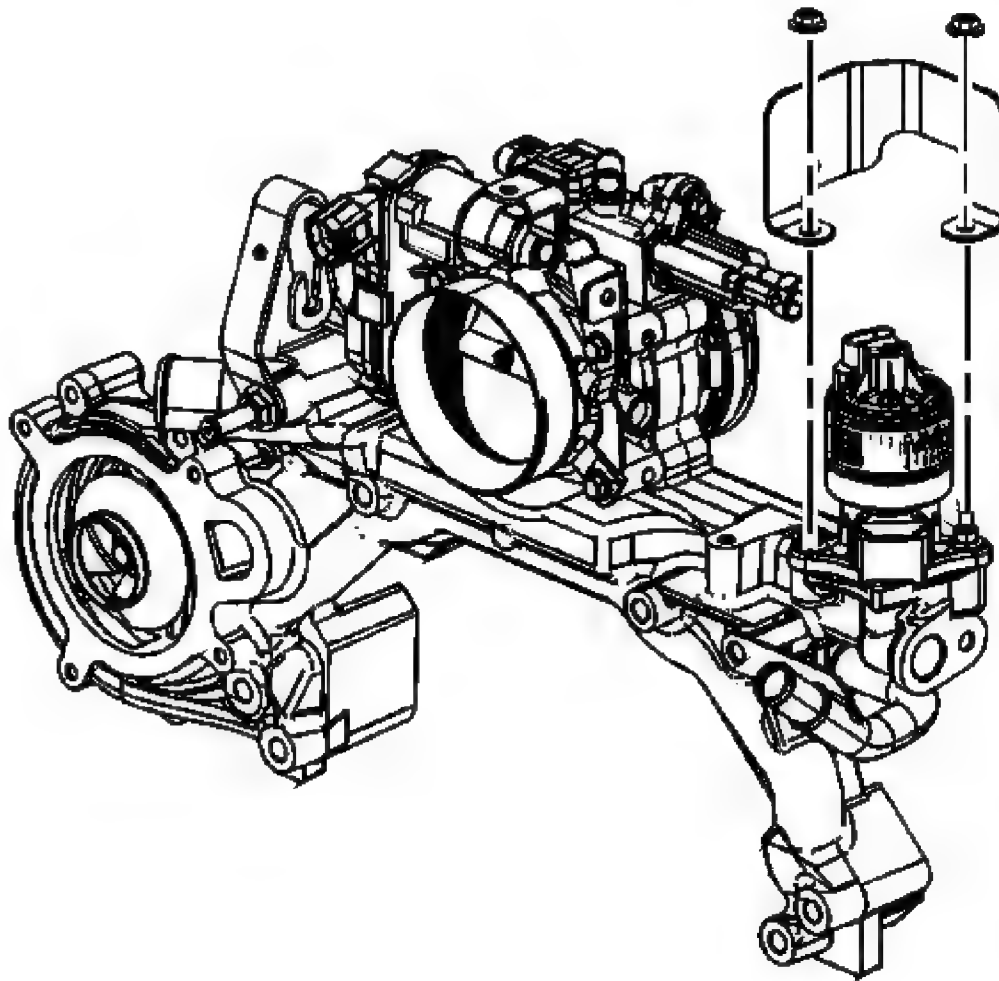


Fig. 137: Identifying EGR Bracket Shield Nuts
Courtesy of GENERAL MOTORS CORP.

6. Remove the EGR bracket shield nut.
7. Remove the EGR bracket shield.

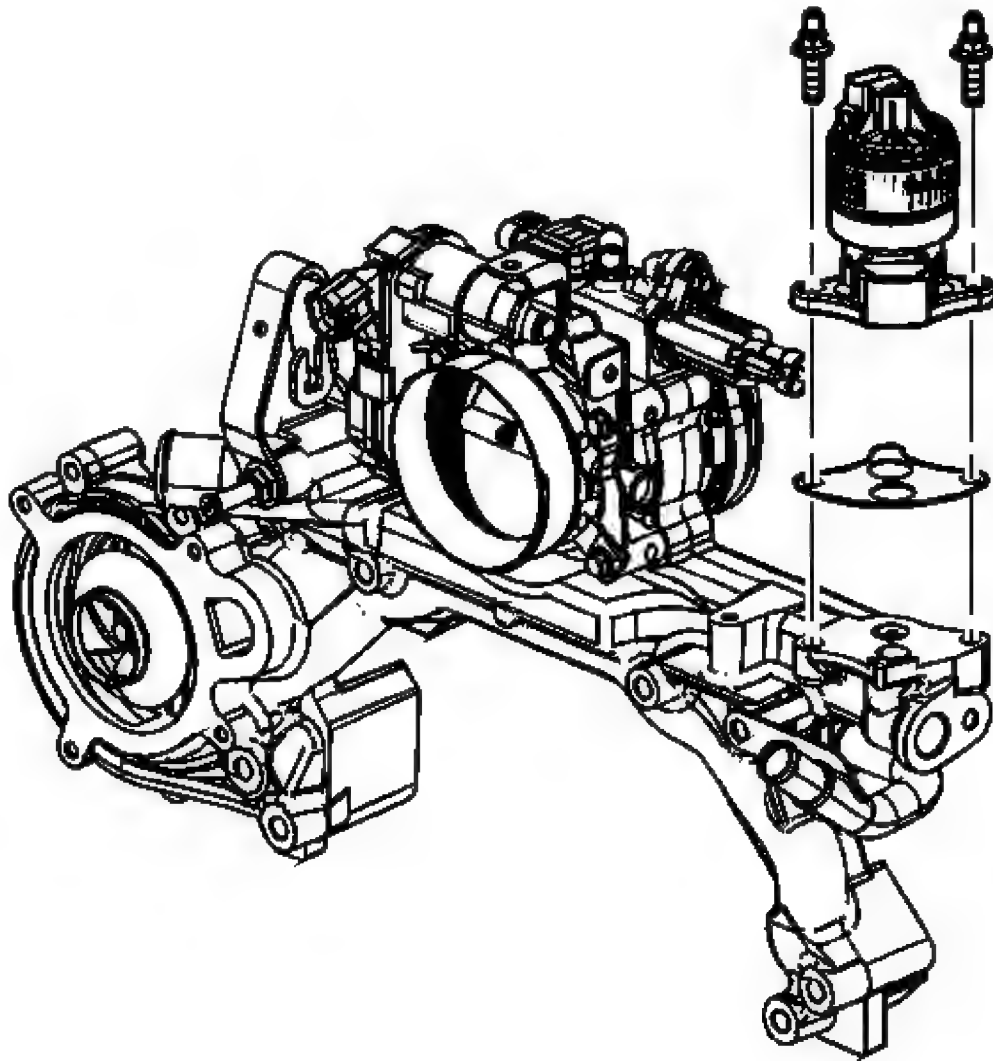


Fig. 138: View Of EGR Valve Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the EGR valve bolts.
9. Remove the EGR valve.
10. Remove and discard the EGR gasket.

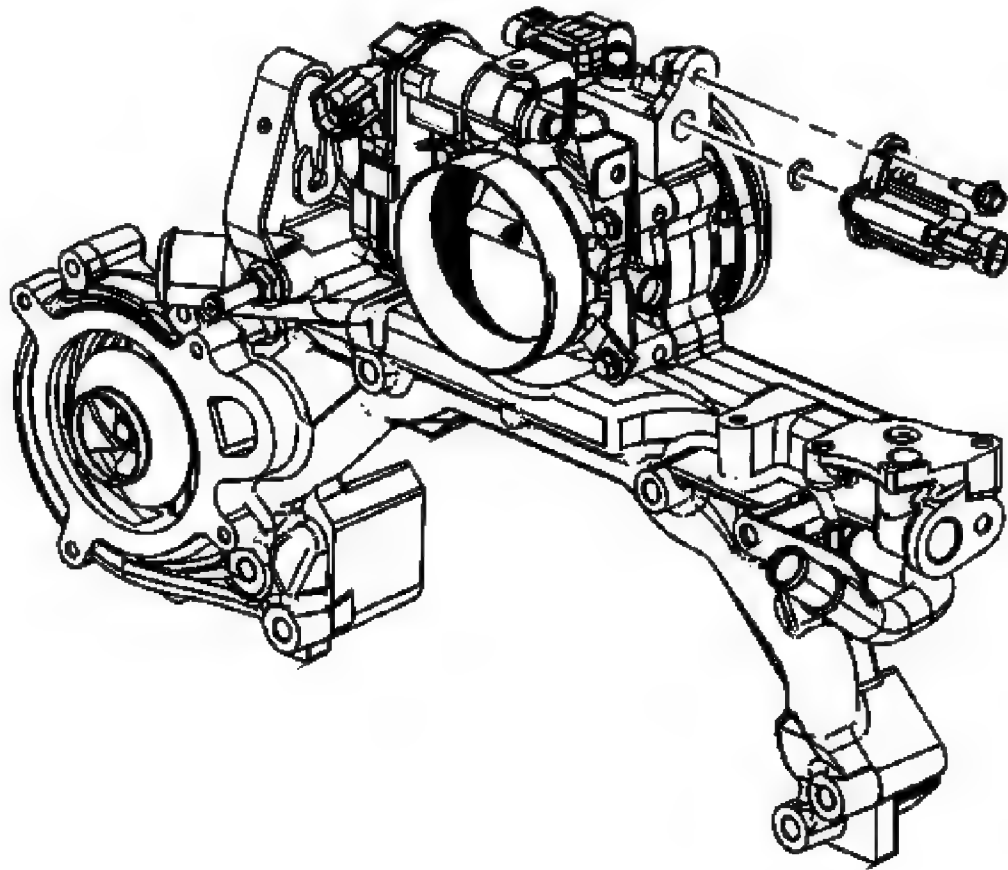


Fig. 139: View Of EVAP Canister Purge Solenoid Valve & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Remove the EVAP emission canister purge valve bolts.
12. Remove the EVAP emission canister purge valve.

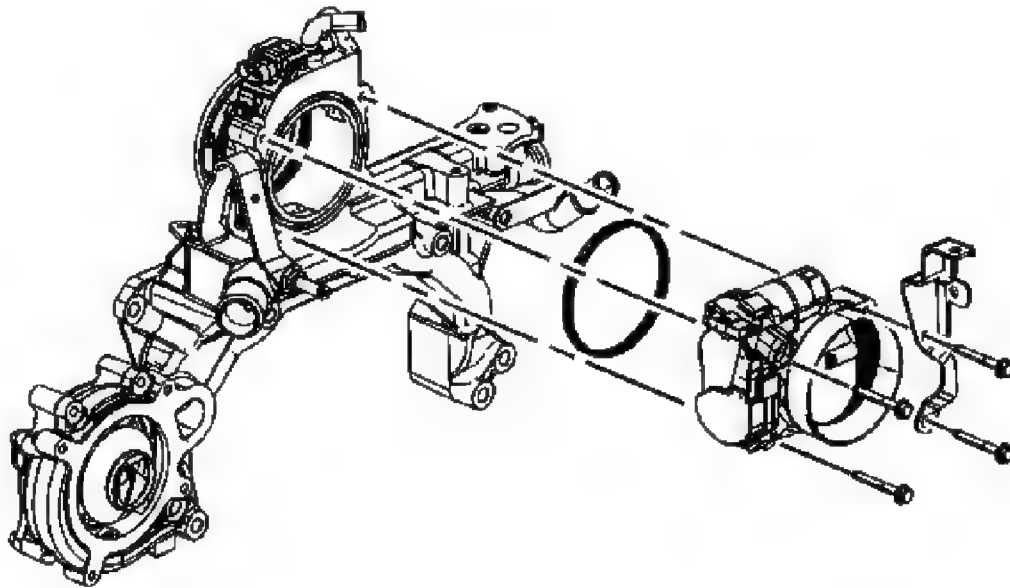


Fig. 140: View Of Throttle Body Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove the throttle body bolts.
14. Remove the shift cable bracket.
15. Remove the throttle body.
16. Remove and discard the throttle body seal.

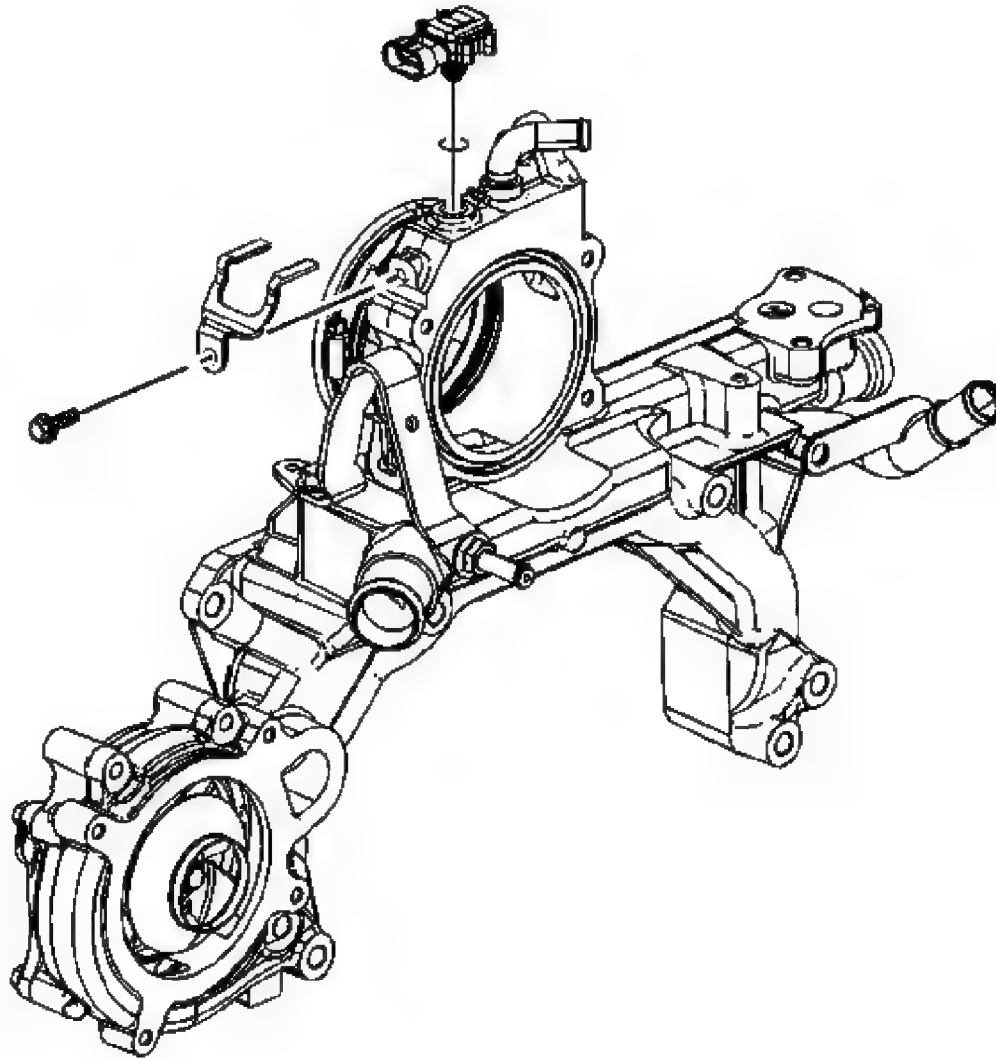


Fig. 141: Identifying MAP Sensor Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

17. Remove the MAP sensor bracket bolt.
18. Remove the MAP sensor bracket.
19. Remove the MAP sensor.

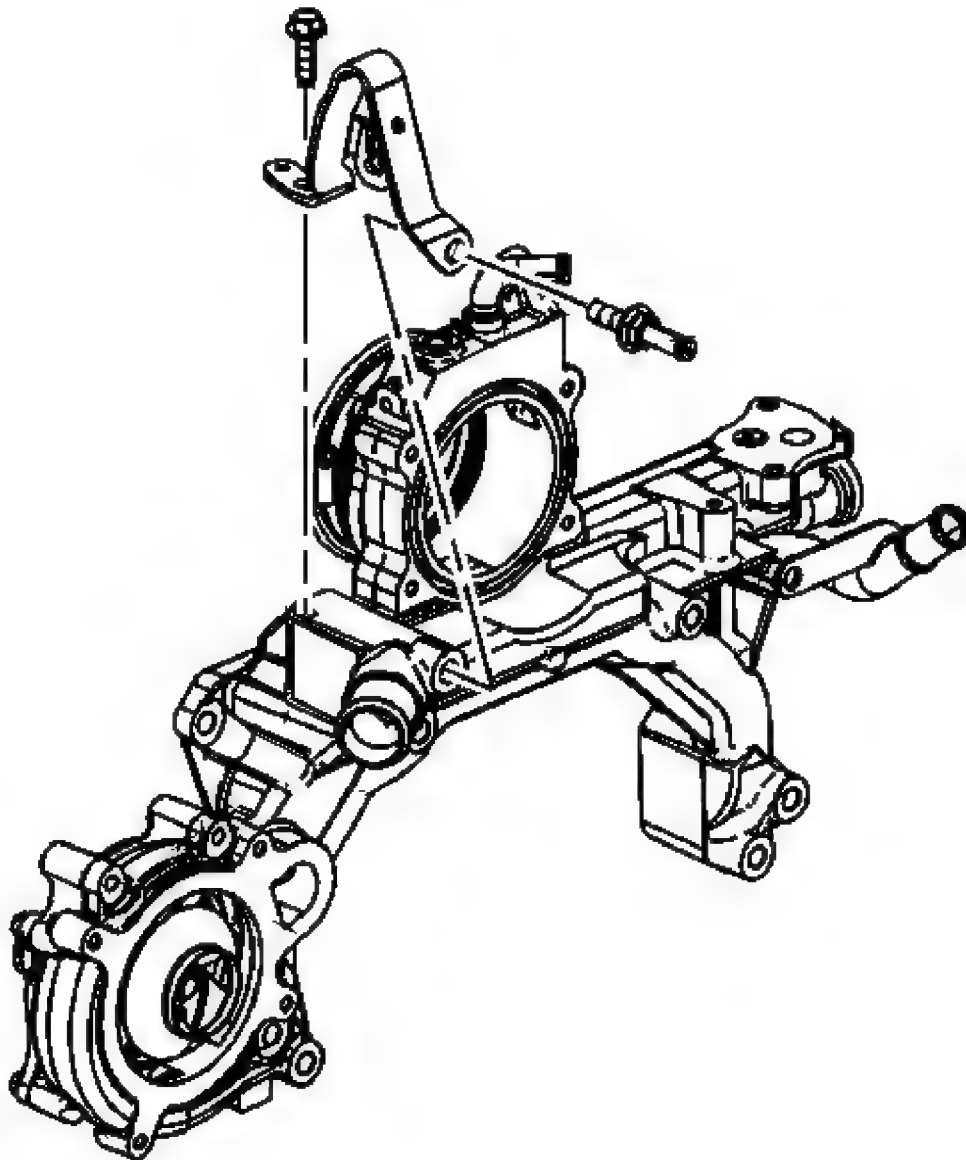


Fig. 142: Identifying Engine Coolant Outlet Fitting
Courtesy of GENERAL MOTORS CORP.

20. Remove the engine coolant outlet fitting.
21. Remove the rear lift bracket bolt.
22. Remove the rear lift bracket.

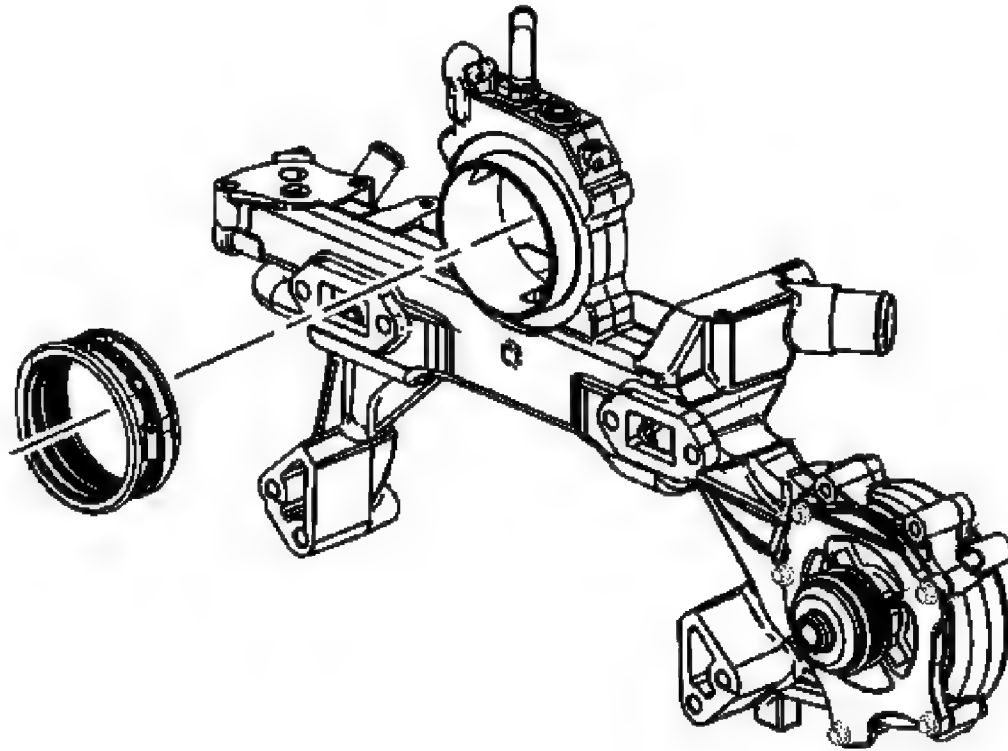


Fig. 143: Identifying Throttle Body Plenum Duct
Courtesy of GENERAL MOTORS CORP.

23. Loosen the throttle body plenum duct clamp.
24. Remove and discard the throttle body plenum duct.

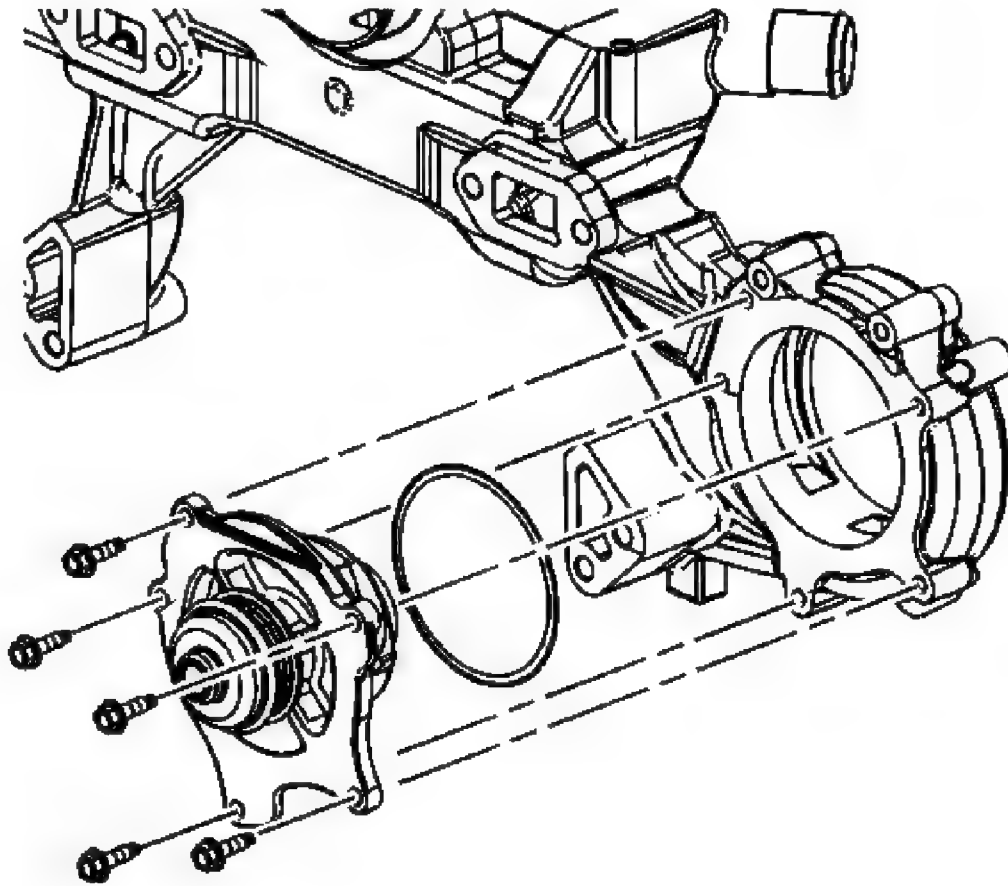


Fig. 144: Identifying Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

25. Remove the water pump bolts.
26. Remove the water pump.

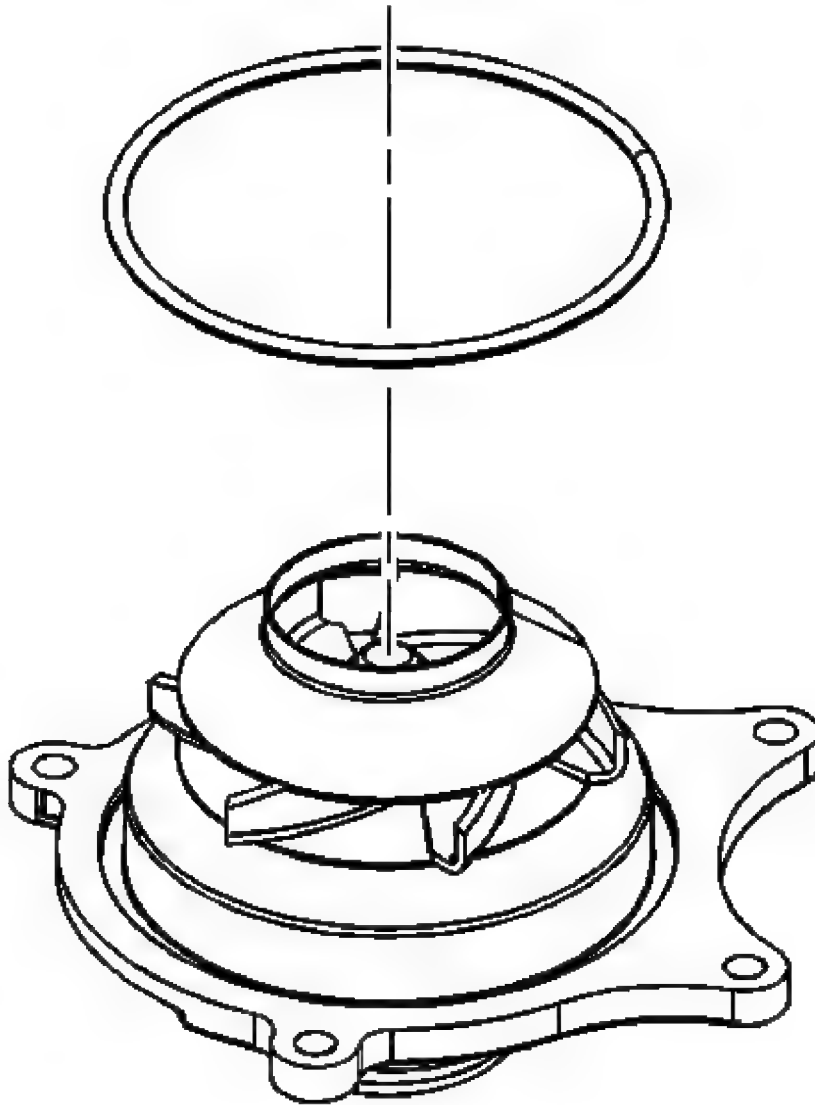


Fig. 145: Identifying Water Pump O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

27. Remove and discard the water pump O-ring.

WATER PUMP CLEANING AND INSPECTION

CLEANING PROCEDURE

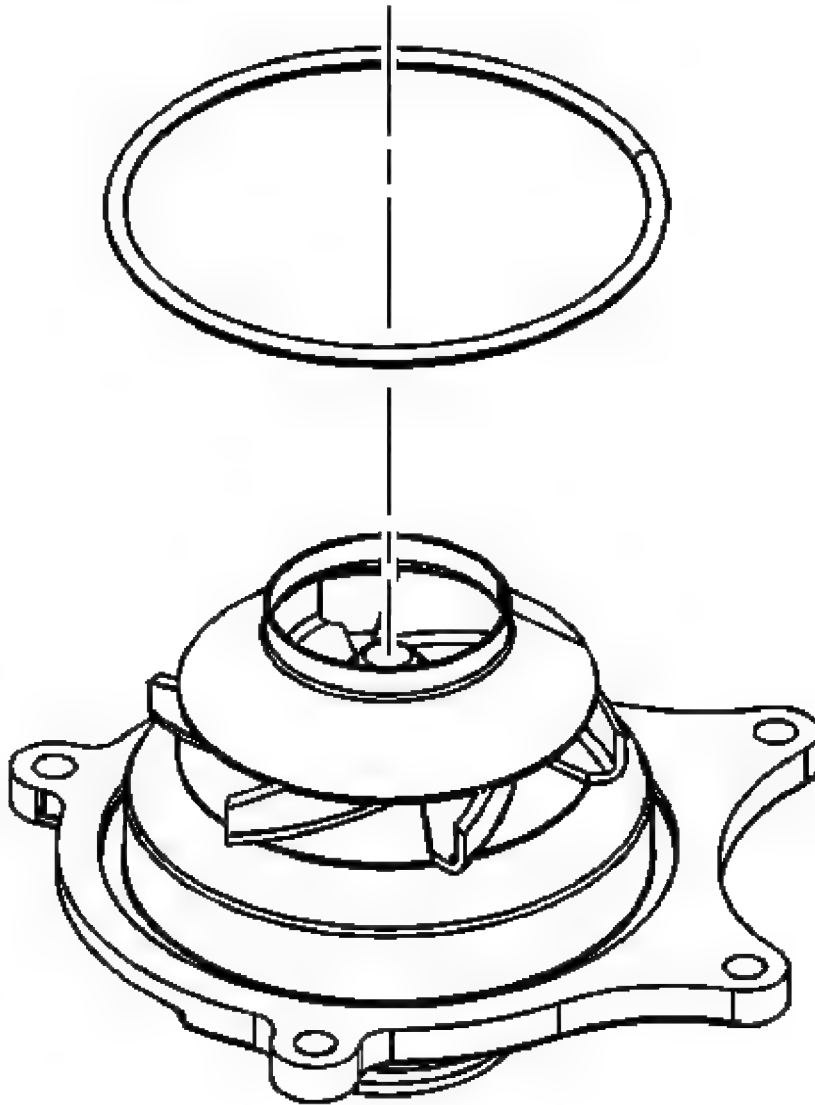


Fig. 146: Identifying Water Pump O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

1. Remove and discard the O-ring from the water pump.
2. Clean all excess dirt and debris from the water pump housing.

INSPECTION PROCEDURE

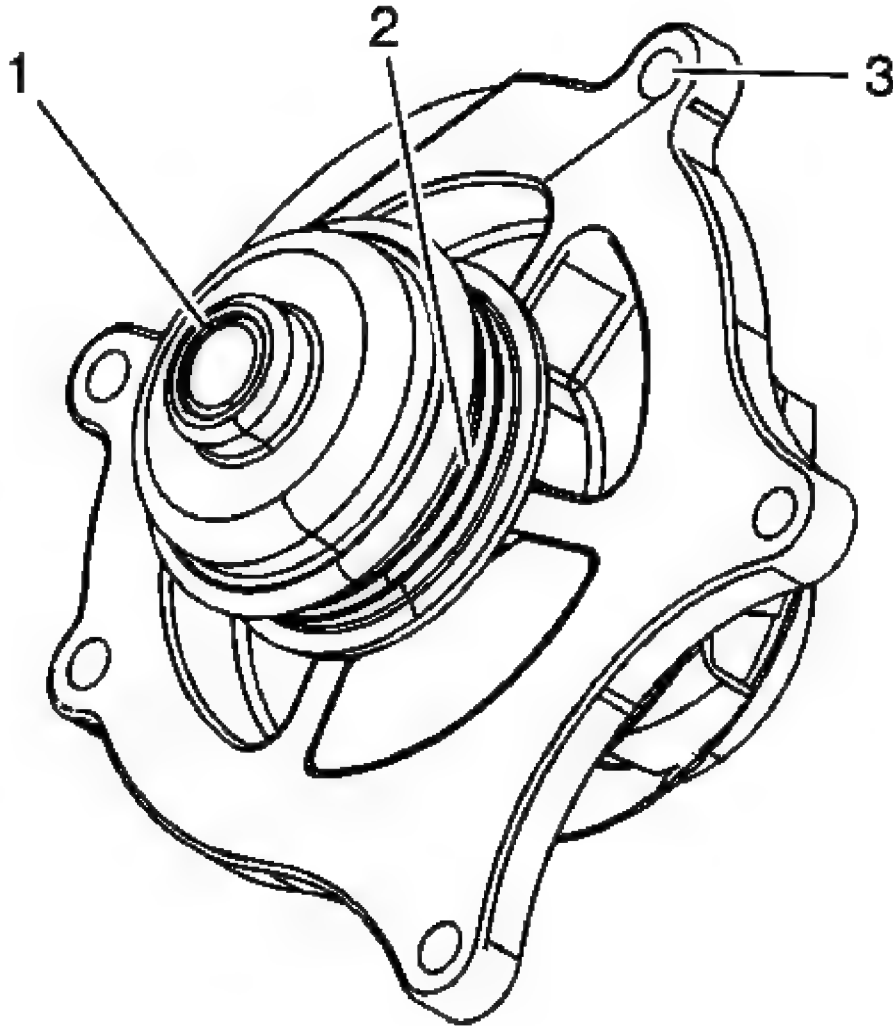


Fig. 147: View Of Water Pump Hub
Courtesy of GENERAL MOTORS CORP.

1. Rotate the water pump hub (1). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy or feels rough when rotated, replace the water pump.
2. Inspect the exterior of the water pump for the following:
 - Damage to the water pump pulley (2)
 - Damage to the water pump bolt holes (3)

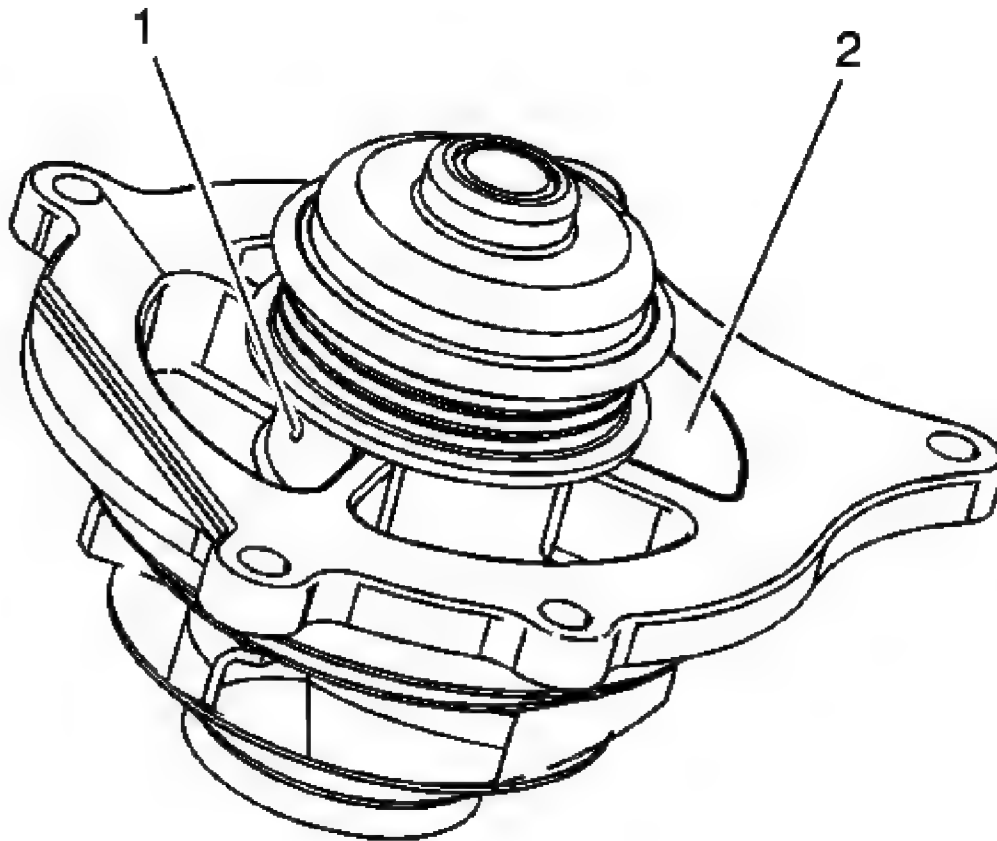


Fig. 148: Identifying Water Pump Shaft Weep Holes
Courtesy of GENERAL MOTORS CORP.

3. Examine the water pump shaft weep holes (1, 2) in the water pump body for signs of leakage. If coolant leakage is evident, replace the water pump.

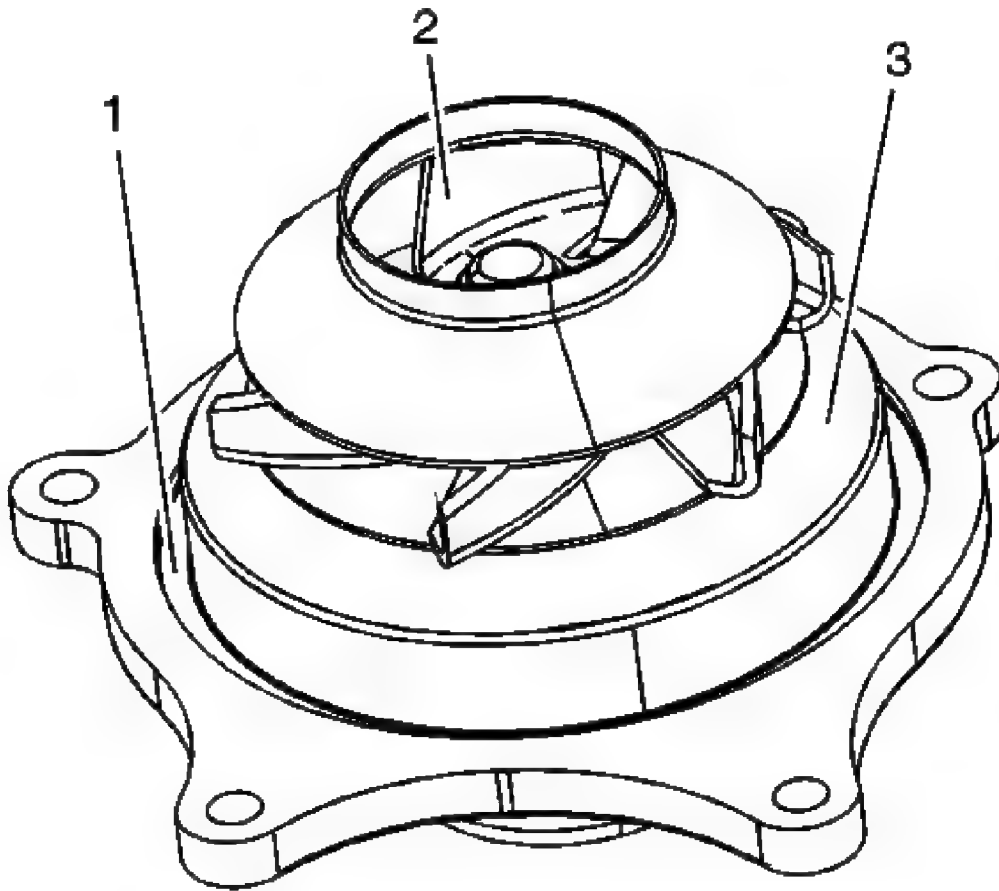


Fig. 149: View Of Interior Of Water Pump
Courtesy of GENERAL MOTORS CORP.

4. Inspect the interior of the water pump for the following:
 - Damage to the water pump O-ring sealing surface (1)
 - Damage, corrosion or restrictions to the water pump impeller (2)
 - Damage, corrosion or restrictions to the coolant passages (3)
5. Repair or replace the water pump as necessary.

WATER CROSSOVER CLEANING AND INSPECTION

CLEANING PROCEDURE

1. Clean the water crossover in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION.

2. Dry the water crossover with compressed air.

INSPECTION PROCEDURE

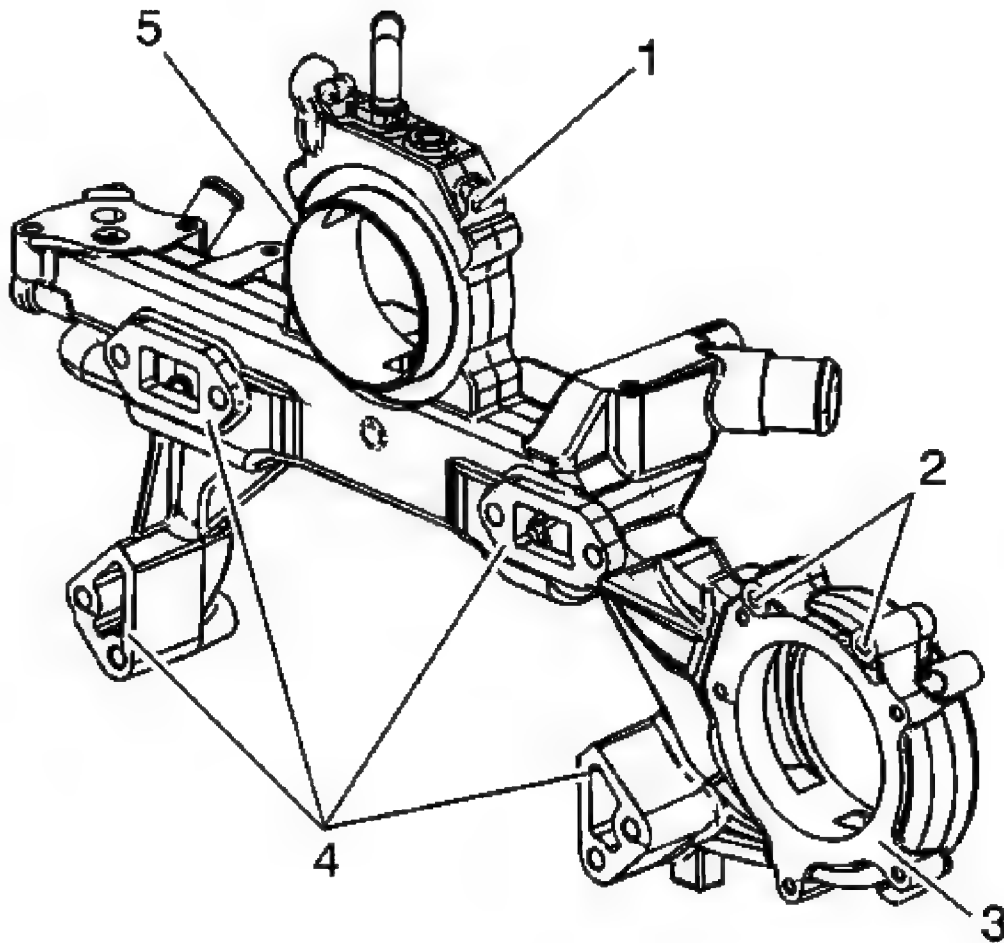


Fig. 150: View Of Water Crossover
Courtesy of GENERAL MOTORS CORP.

1. Inspect the water crossover for the following:
 - Corrosion or damage to the threads for the MAP sensor bracket bolt (1).
 - Corrosion or damage to the water pump drive belt tensioner/shield mounting bolt holes (2)
 - Corrosion or damage to the water pump sealing area (3)

- Corrosion or damage to the gasket sealing surfaces (4)
- Corrosion or damage to the plenum duct sealing area (5)

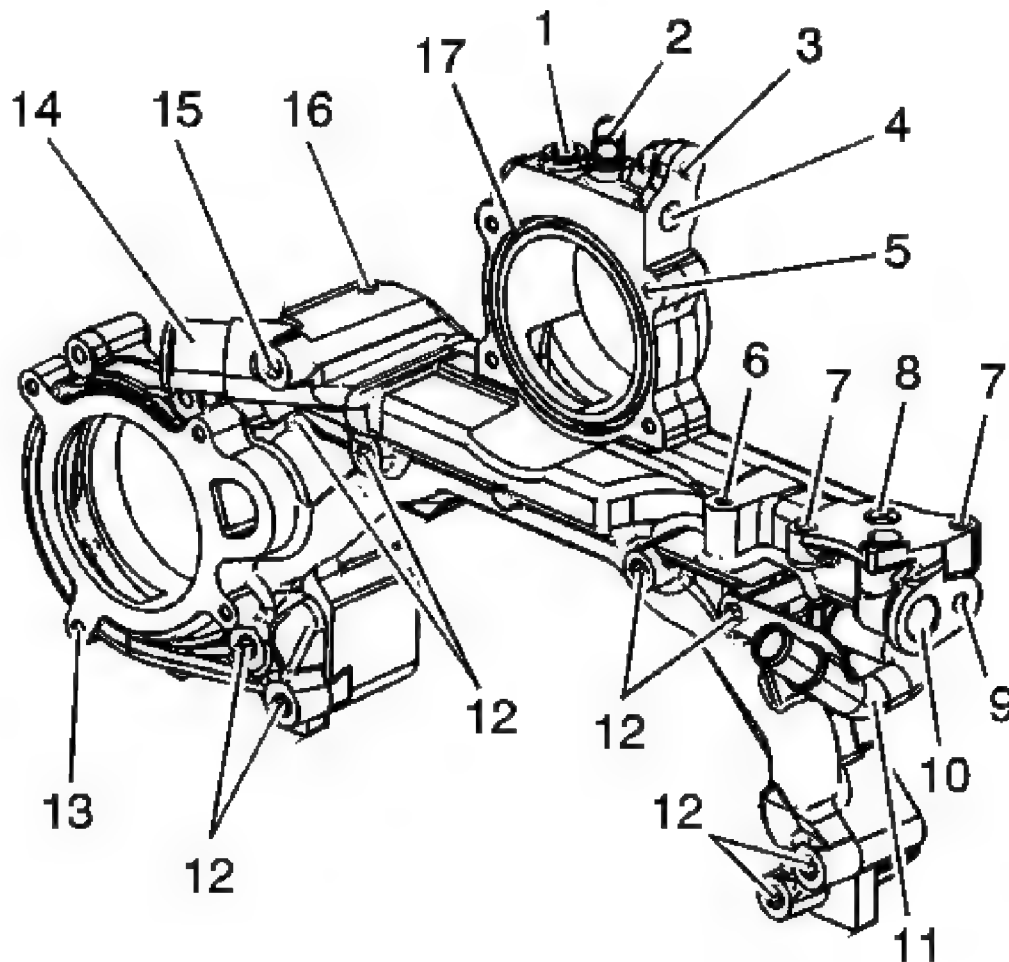


Fig. 151: Identifying Water Crossover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the water crossover for the following:
 - Corrosion, restrictions or damage to the seal/gasket sealing surfaces for the following:
 - MAP sensor vacuum source port (1)
 - Brake booster vacuum hose source port fitting (2)
 - EVAP emission canister purge valve port (4)
 - EGR valve port (8)

- EGR inlet pipe port (10)
 - Throttle body mounting surface (17)
 - Corrosion or damage to the threads for the following connections:
 - EVAP emission canister purge valve mounting bolt hole (3)
 - Fuel rail bracket mounting bolt hole (6)
 - EGR valve mounting bolt holes (7)
 - EGR inlet pipe mounting bolt holes (9)
 - Water pump cover bolt holes (13)
 - Engine coolant outlet fitting hole (15)
 - Engine lift bracket bolt holes (16)
 - Corrosion or damage to the throttle body fastener bolt holes (5)
 - Corrosion or damage to the heater inlet fitting (11)
 - Corrosion or damage to the fastener bolt holes (12)
 - Corrosion or damage to the radiator hose outlet (14)
3. Inspect for damage or serviceability the following components:
- Water pump and seal
 - Thermostat and seal
 - Water outlet
 - Water pump cover and seal
 - MAP sensor and seal
 - Automatic transmission range selector lever clamp bracket
 - Throttle body
 - Throttle body O-ring
 - Throttle body spacer
 - EGR valve
 - EGR bracket shield
 - EVAP emission canister purge valve
 - Rear lift bracket
 - Engine coolant outlet fitting
 - Heater inlet fitting
 - Bolts and fasteners
4. Repair or replace the water crossover and/or components as necessary.

WATER CROSSOVER ASSEMBLE

ASSEMBLY PROCEDURE

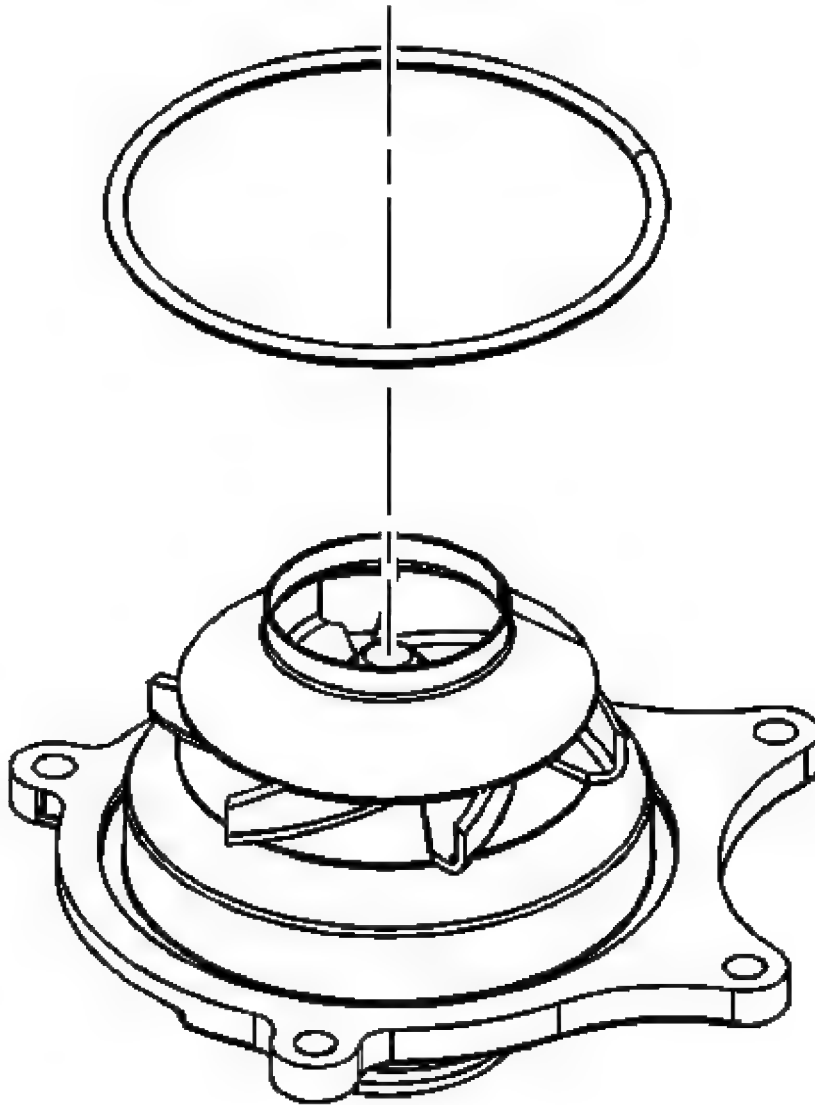


Fig. 152: Identifying Water Pump O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW water pump O-ring.

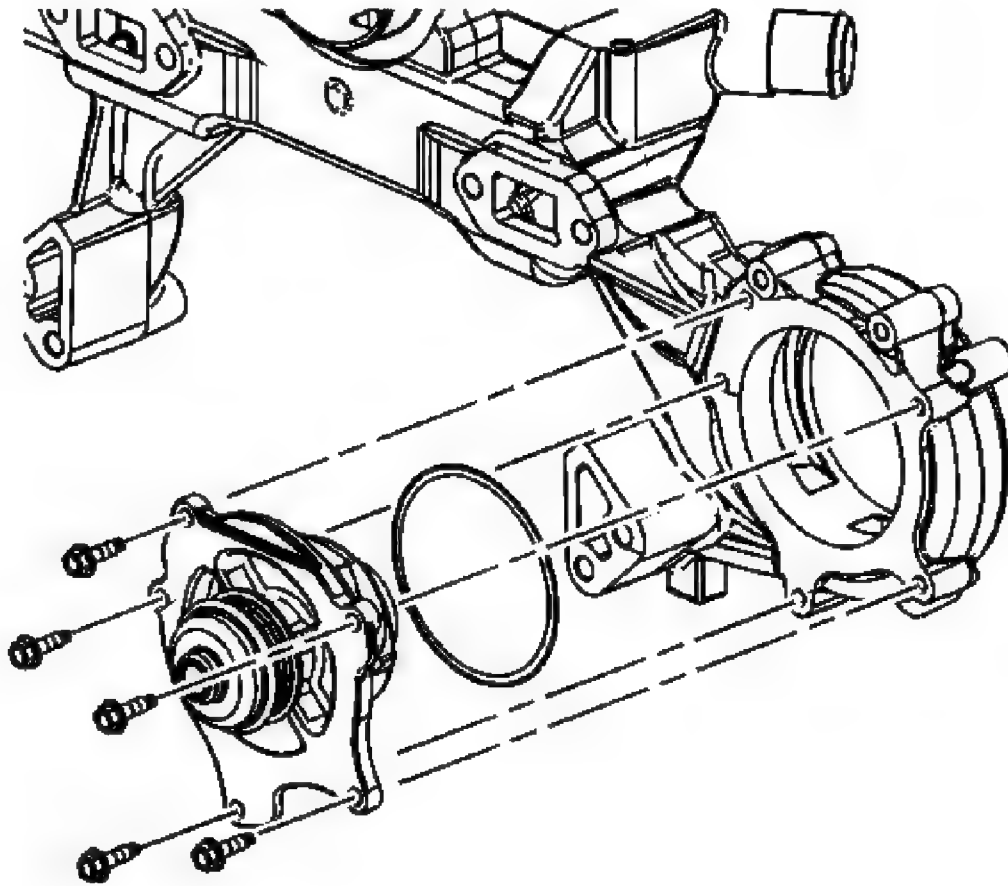


Fig. 153: Identifying Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the water pump.

NOTE: Refer to SPECIAL FASTENER NOTICE .

3. Install the water pump bolts.

Tighten: Tighten the water pump bolts to 10 N.m (89 lb in).

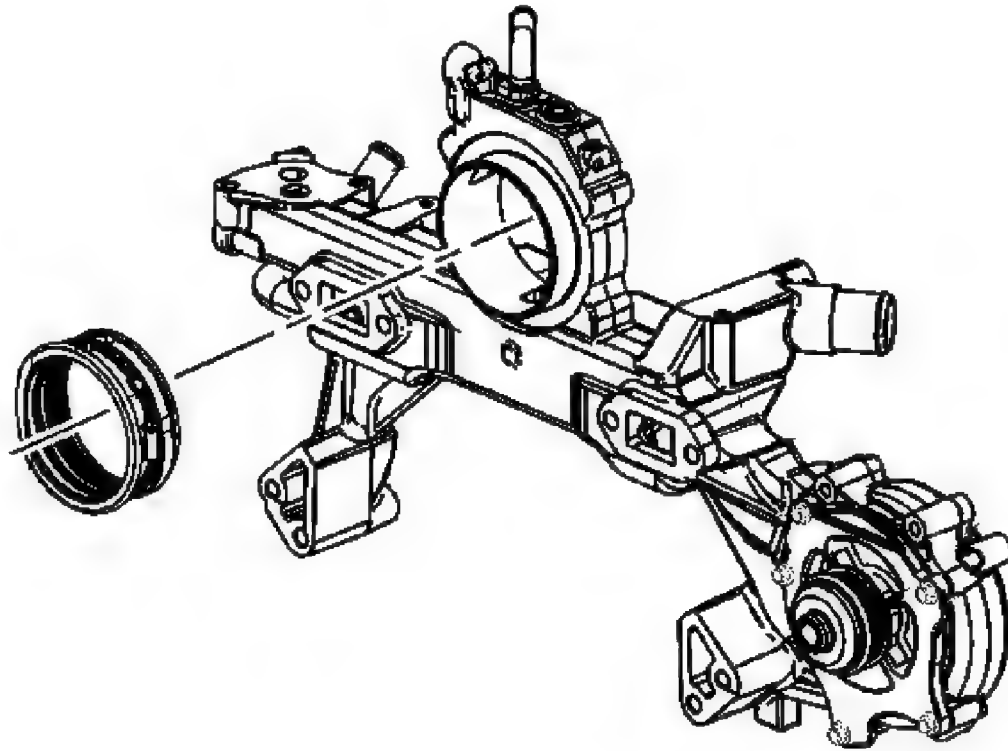


Fig. 154: Identifying Throttle Body Plenum Duct
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any type of sealant between the plenum duct and the water crossover.

4. Install the NEW throttle body plenum duct.

Tighten: Tighten the throttle body plenum duct clamp to 2.25 N.m (20 lb in).

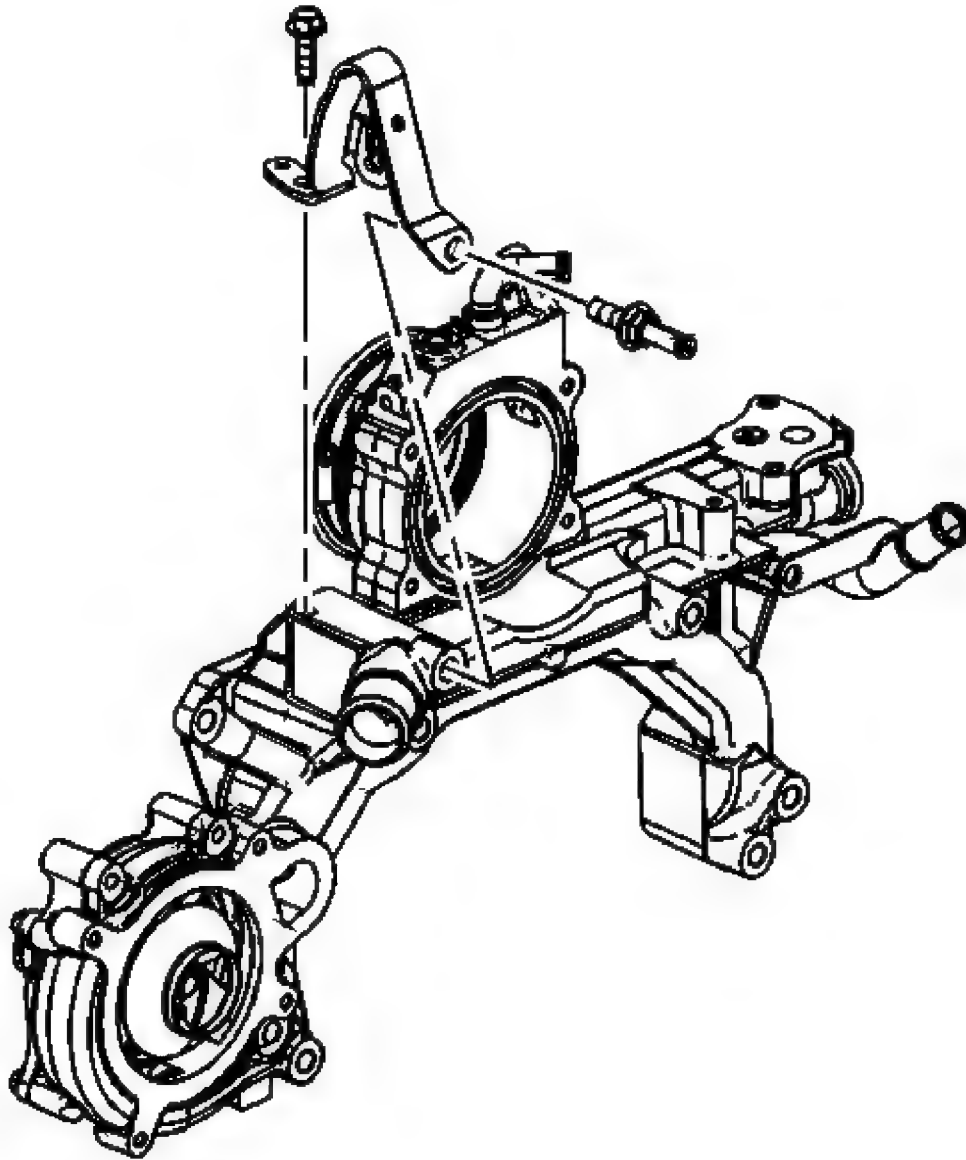


Fig. 155: Identifying Engine Coolant Outlet Fitting
Courtesy of GENERAL MOTORS CORP.

5. Install the rear lift bracket.
6. Install the rear lift bracket bolt.

Tighten: Tighten the rear lift bracket bolt to 25 N.m (18 lb ft).

7. Install the engine coolant outlet fitting.

Tighten: Tighten the engine coolant outlet fitting to 53 N.m (39 lb ft).

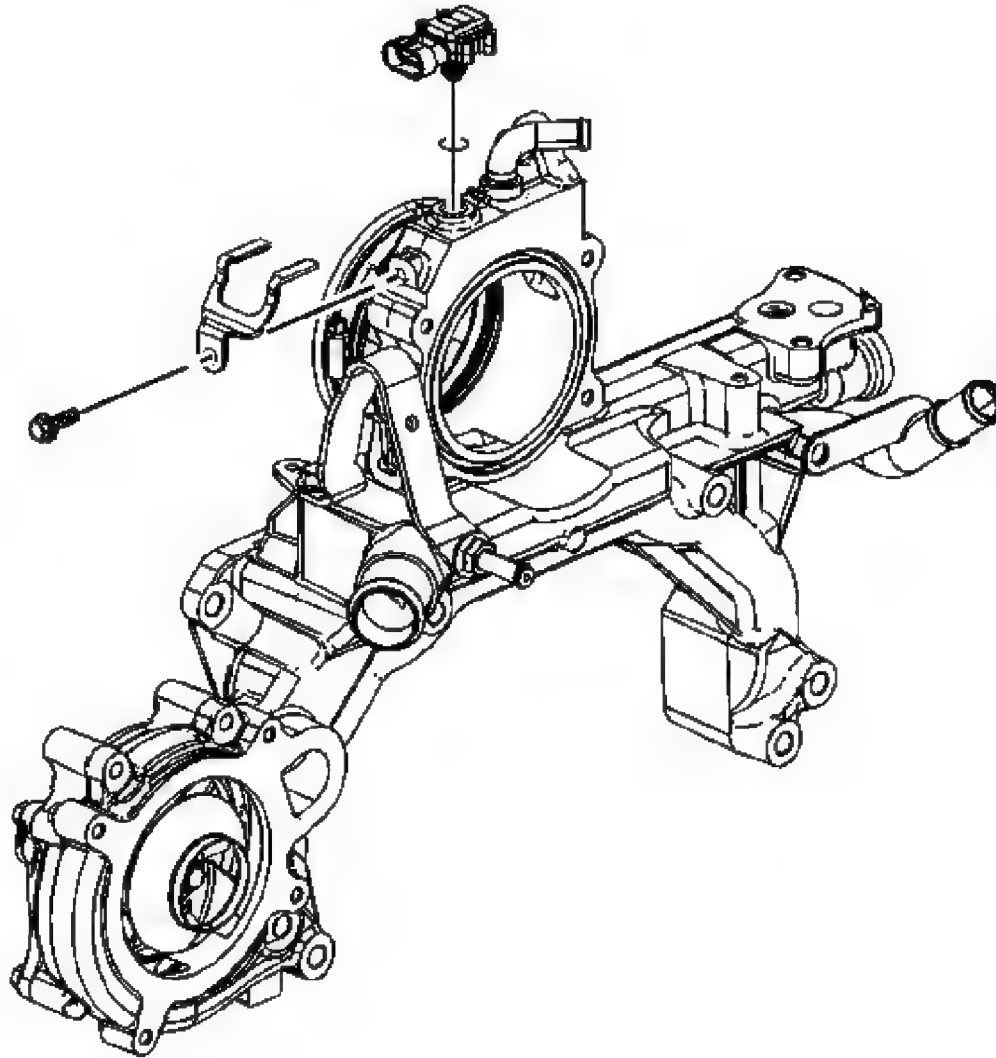


Fig. 156: Identifying MAP Sensor Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the MAP sensor.
9. Install the MAP sensor bracket.
10. Install the MAP sensor bracket bolt.

Tighten: Tighten the MAP sensor bracket bolt to 10 N.m (89 lb in).

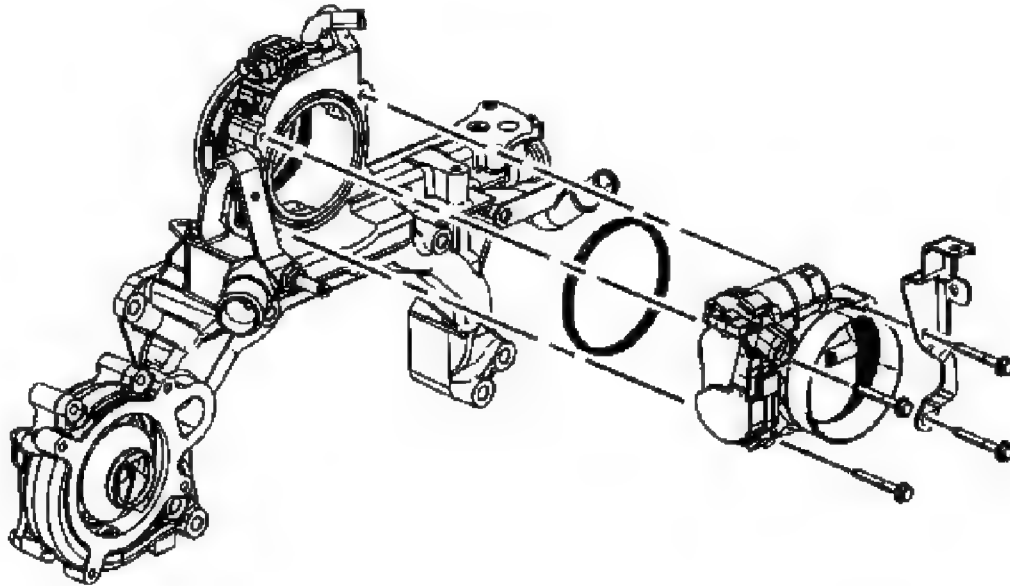


Fig. 157: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

11. Install the NEW throttle body seal.
12. Install the throttle body.
13. Install the shift cable bracket.
14. Install the throttle body bolts.

Tighten: Tighten the throttle body bolts to 10 N.m (89 lb in).

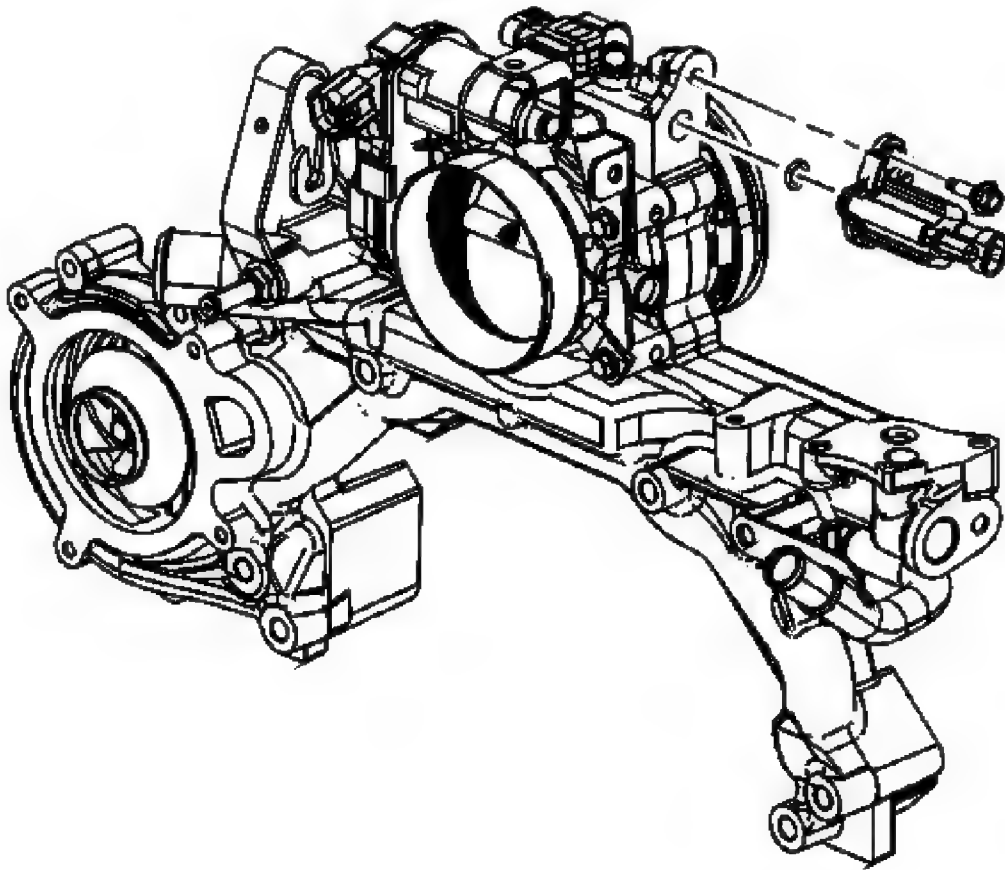


Fig. 158: View Of EVAP Canister Purge Solenoid Valve & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Install the EVAP emission canister purge valve.
16. Install the EVAP emission canister purge valve bolts.

Tighten: Tighten the EVAP emission canister purge valve bolts to 10 N.m (89 lb in).

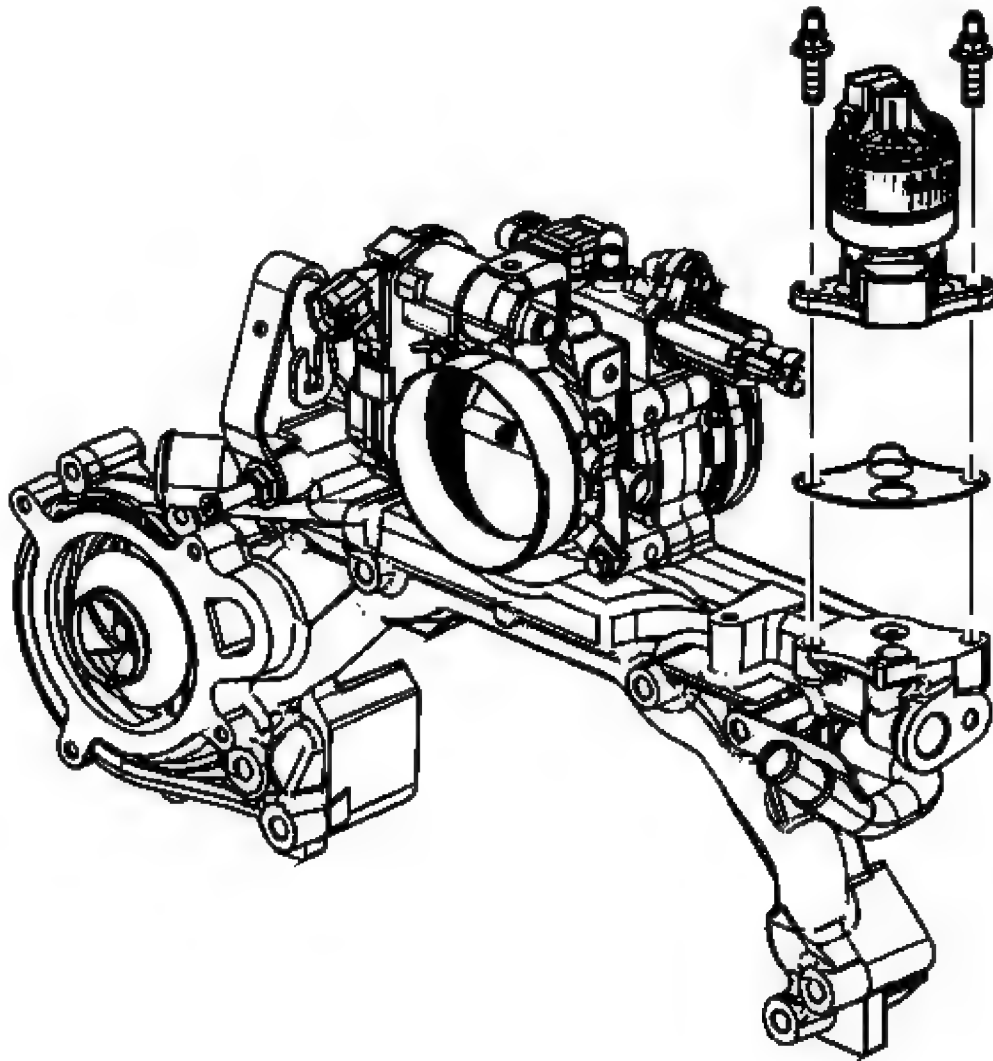


Fig. 159: View Of EGR Valve Bolts
Courtesy of GENERAL MOTORS CORP.

17. Install the NEW EGR gasket.
18. Install the EGR valve.
19. Install the EGR valve bolts.

Tighten: Tighten the EGR valve bolts to 24 N.m (17 lb ft).

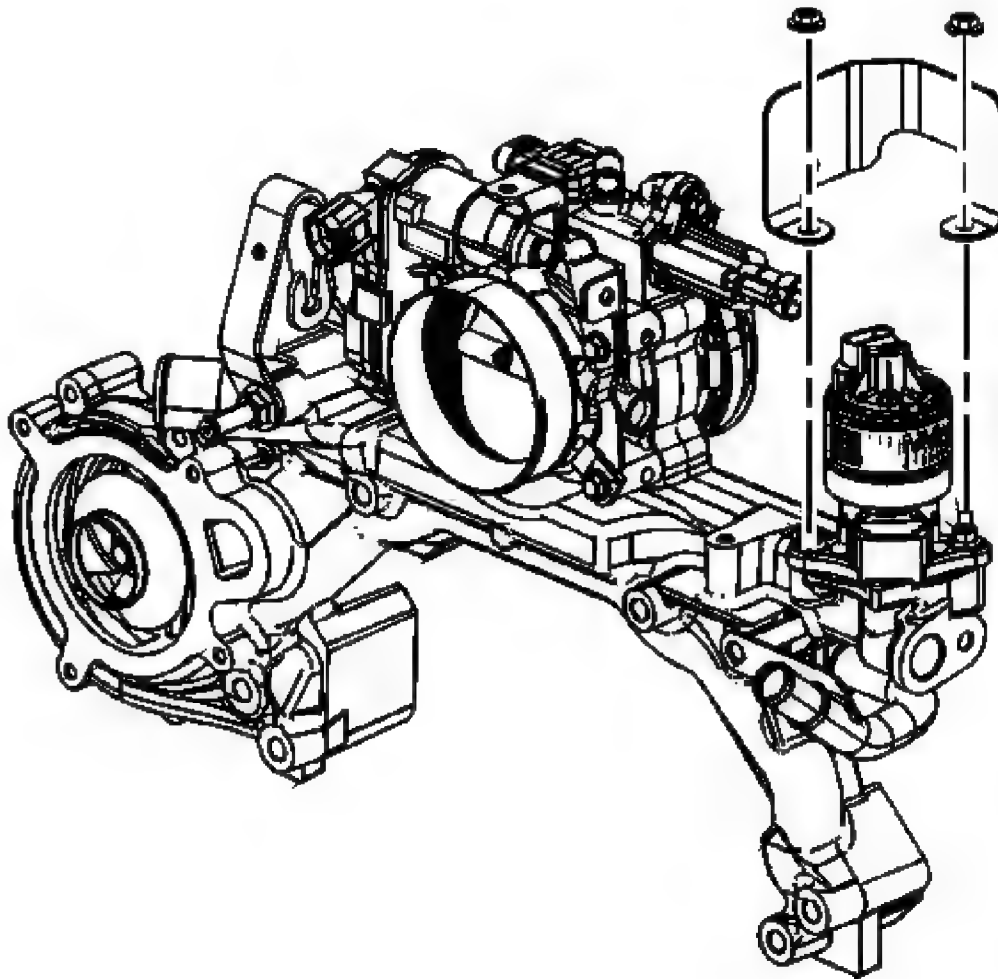


Fig. 160: Identifying EGR Bracket Shield Nuts
Courtesy of GENERAL MOTORS CORP.

20. Install the EGR bracket shield.
21. Install the EGR bracket shield nut.

Tighten: Tighten the EGR bracket shield nuts to 10 N.m (89 lb in).

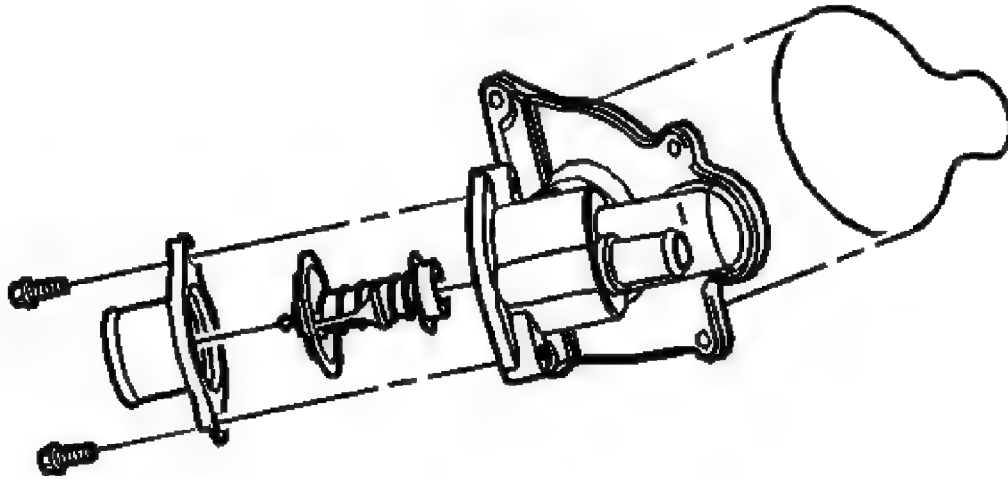


Fig. 161: View of Water Outlet & Thermostat
Courtesy of GENERAL MOTORS CORP.

22. Install the water outlet and thermostat.
23. Install the water outlet bolts.

Tighten: Tighten the water outlet bolts to 10 N.m (89 lb in).

24. Install the NEW water pump cover gasket.

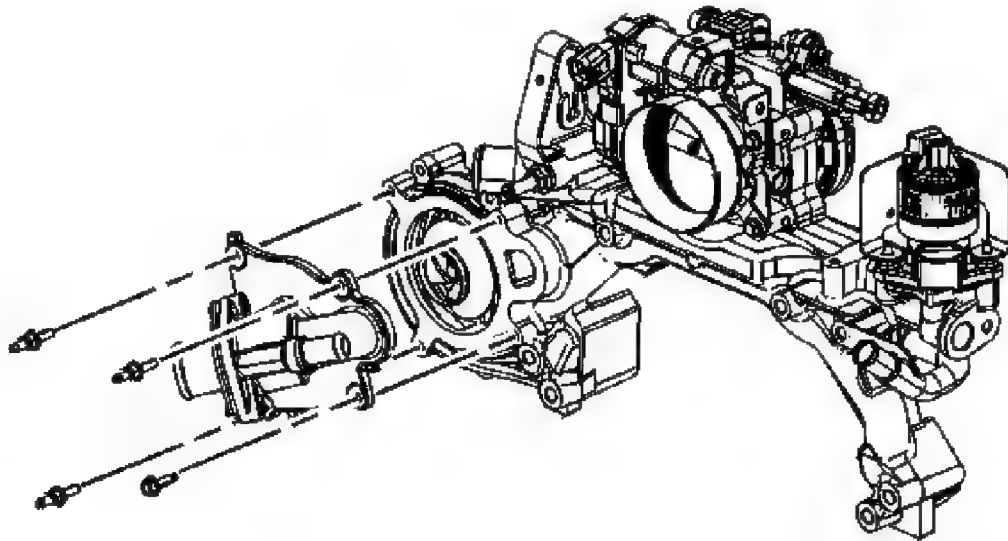


Fig. 162: View Of Water Pump Cover, Bolt & Studs
Courtesy of GENERAL MOTORS CORP.

25. Install the water pump cover.

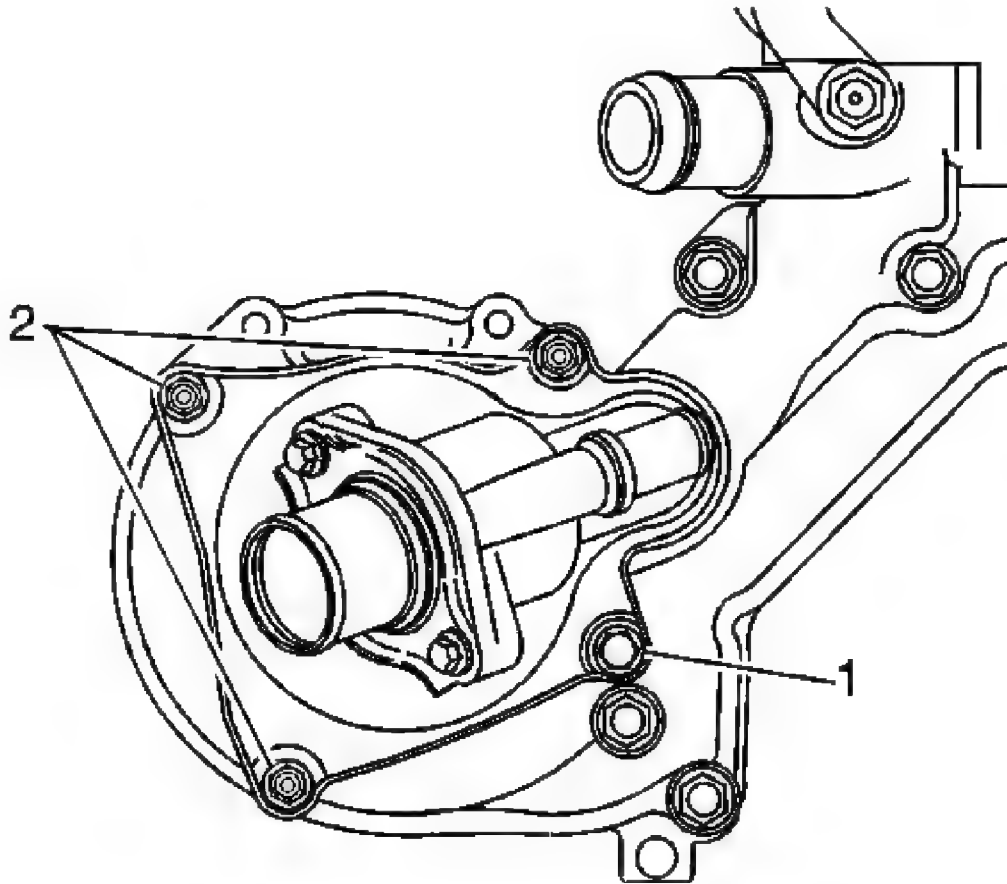


Fig. 163: Illustrating Proper Bolt & Stud Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the bolt is installed in the lower inboard position (1) and the studs are installed in the remaining positions (2).

26. Install the water pump cover bolt and studs.

Tighten: Tighten the water pump cover bolt and studs to 10 N.m (89 lb in).

THREAD REPAIR

TOOLS REQUIRED

- J 42385-2000 Thread Insert Kit. See Special Tools .

- **J 42385-2030** M11 x 2. See **Special Tools** .0 Cylinder Head Bolt - Northstar/Premium V8 Thread Repair Kit
- **J 43965** Thread Repair Extension Kit. See **Special Tools** .

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.

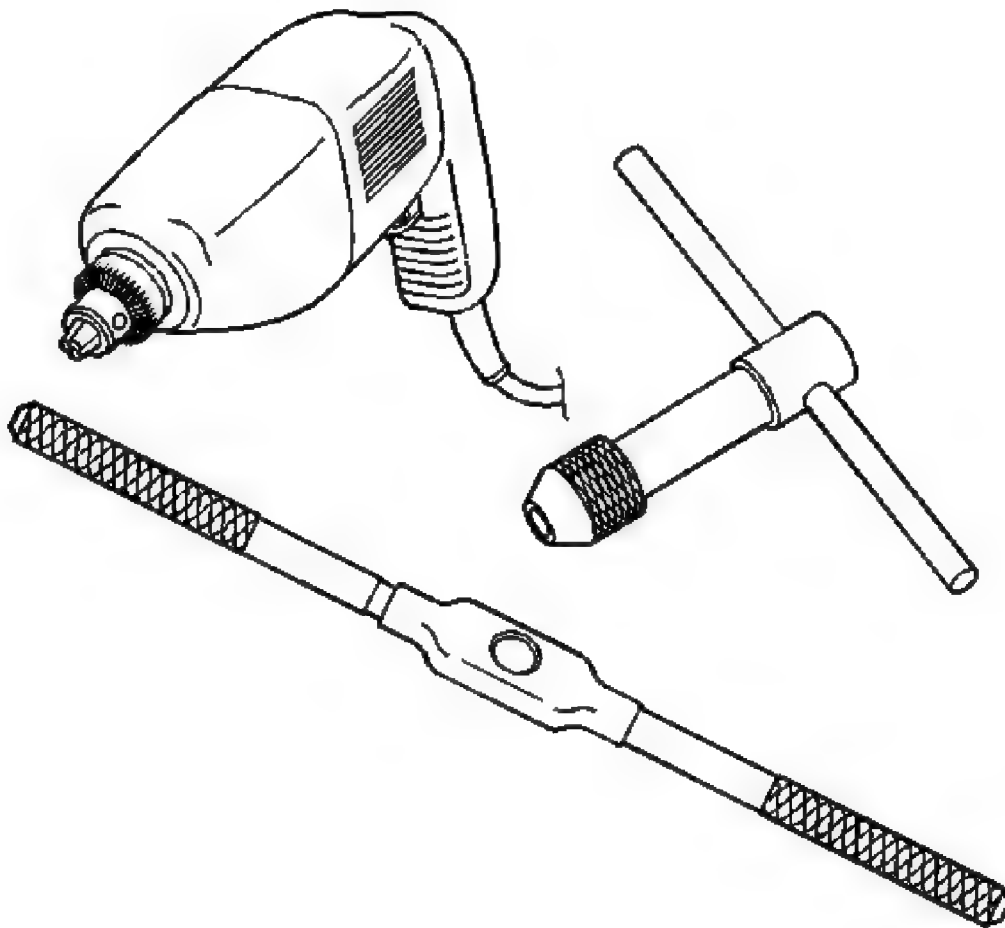


Fig. 164: View Of J 42385-400 Tool Kit
Courtesy of GENERAL MOTORS CORP.

The drill bit and counter bore tool from the tool kit **J 42385-2000** and **J 42385-2030** is designed for use with either a suitable tap wrench or drill motor. See **Special Tools** . Limited access and larger hole repair may process better using a tap wrench. An extension from kit **J**

43965 may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. See **Special Tools** . Use only a tap wrench when tapping the hole and during installation of the insert.

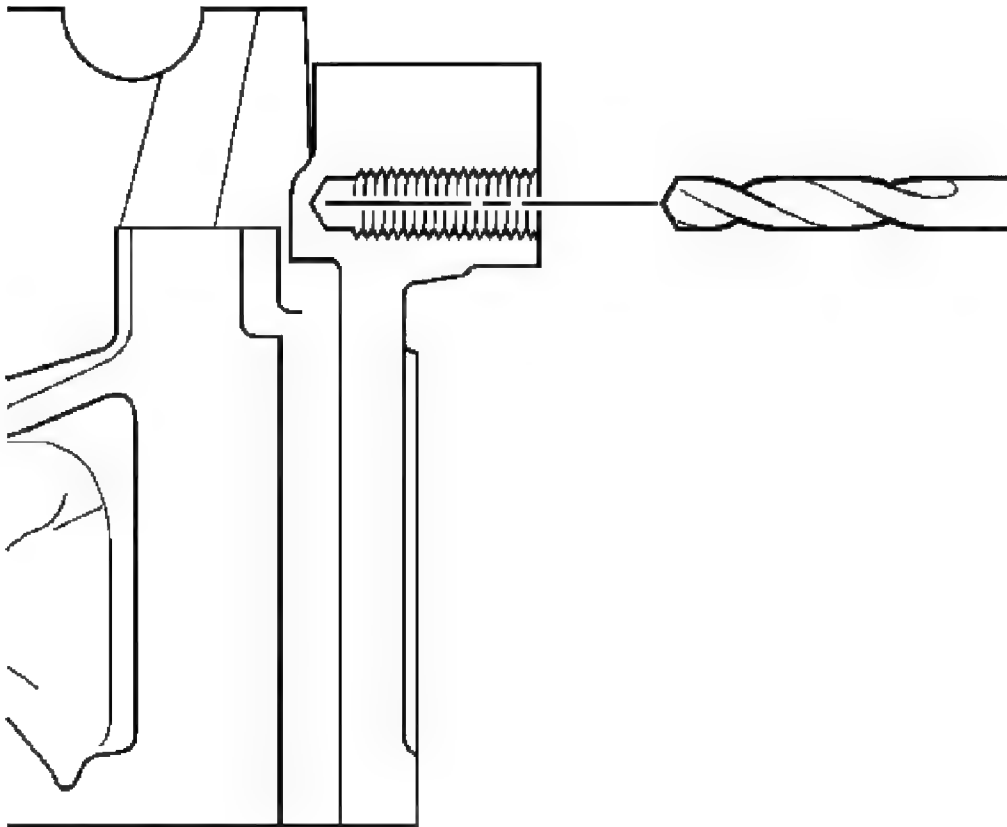


Fig. 165: Drilled Hole Centerline
Courtesy of GENERAL MOTORS CORP.

It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

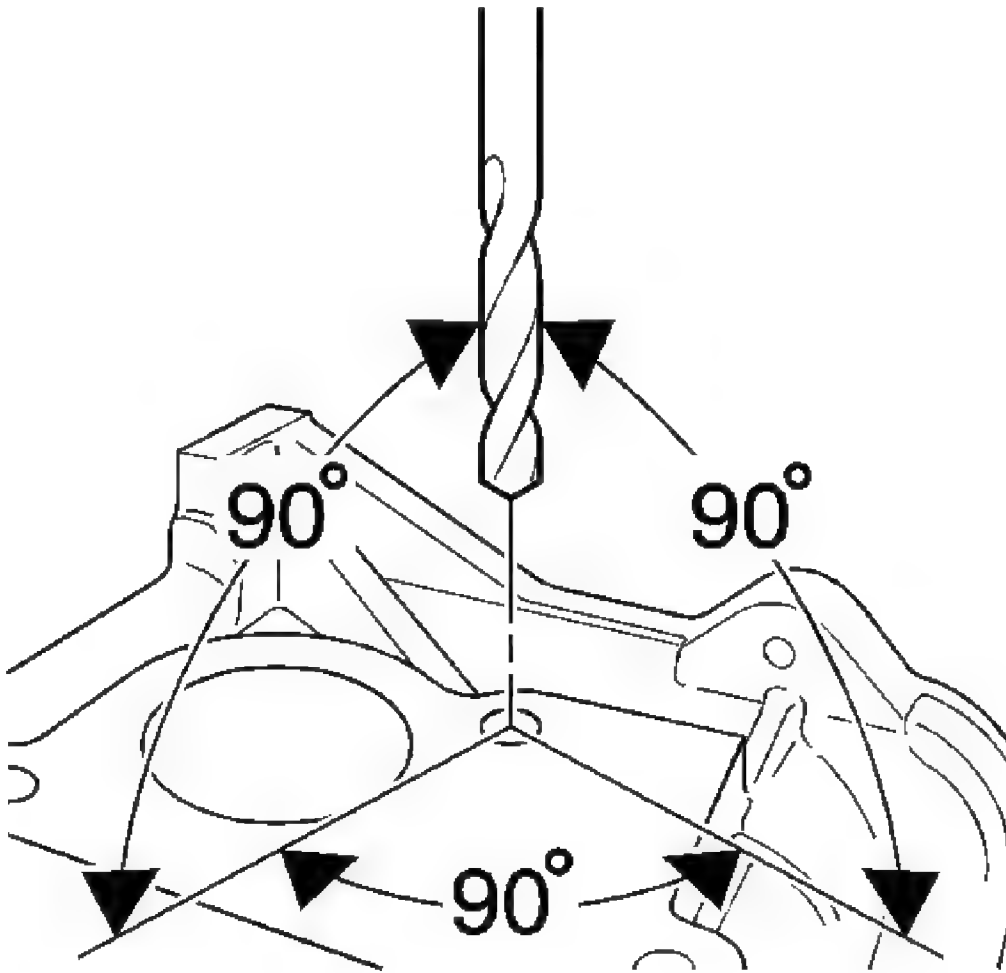


Fig. 166: Identifying Proper Drilling Angle
Courtesy of GENERAL MOTORS CORP.

During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

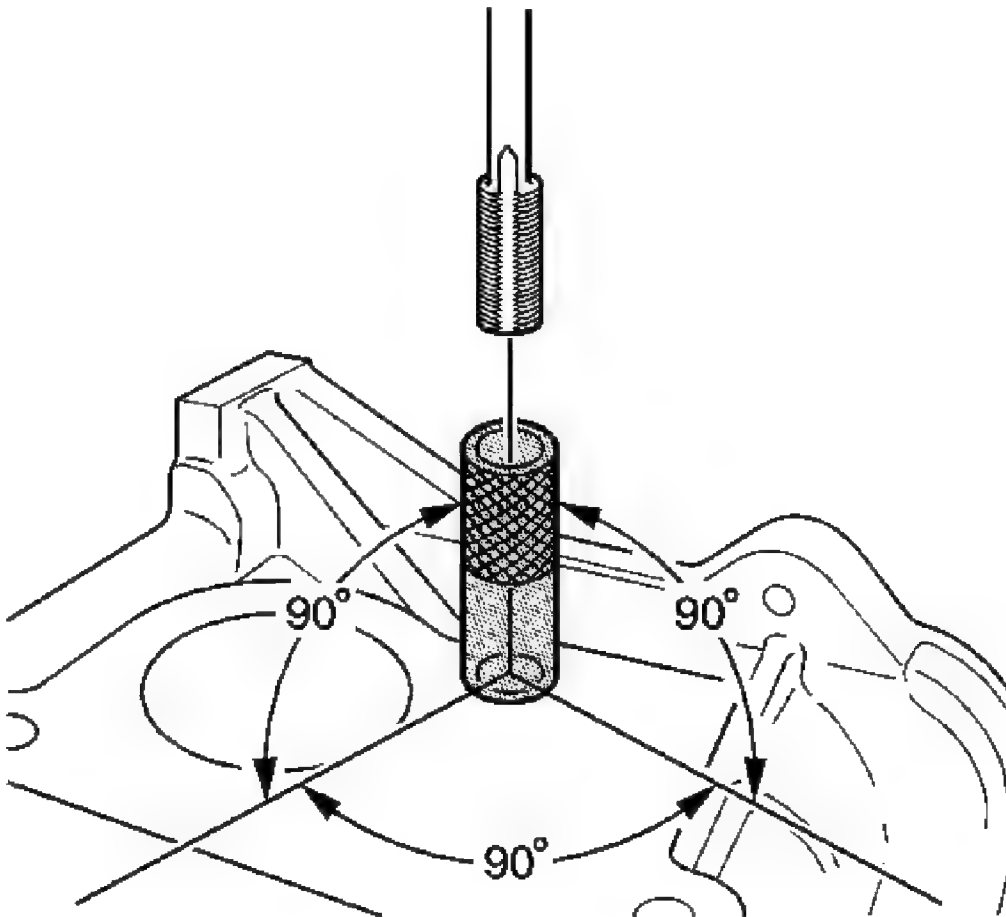


Fig. 167: View Of Tapping Guide

Courtesy of **GENERAL MOTORS CORP.**

If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Thread Repair

Tap Size	Tap Guide	Tape Size	Tape Guide	Tap Size	Tape Guide
-	J 42385-	-	J 42385-	-	J 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

STANDARD THREAD REPAIR - FLUSH HOLE

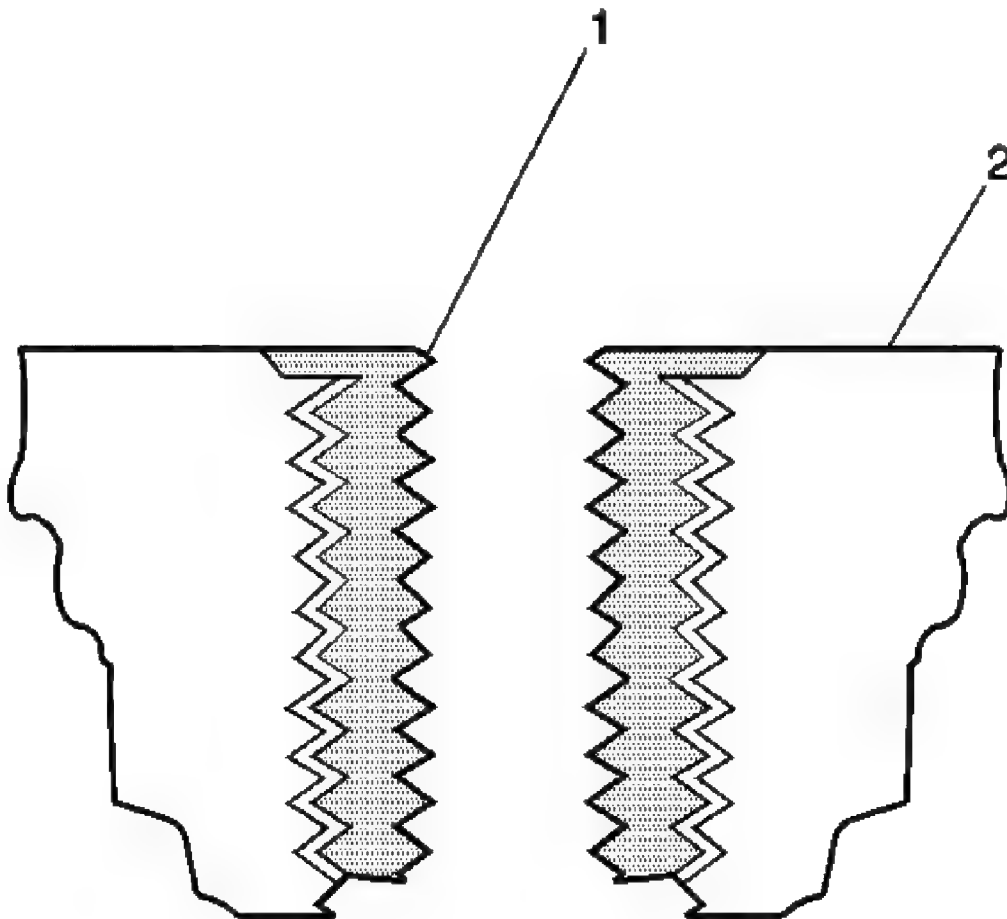


Fig. 168: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against the counterbore of the drilled/tapped hole and just below the surface (2) of the base material.

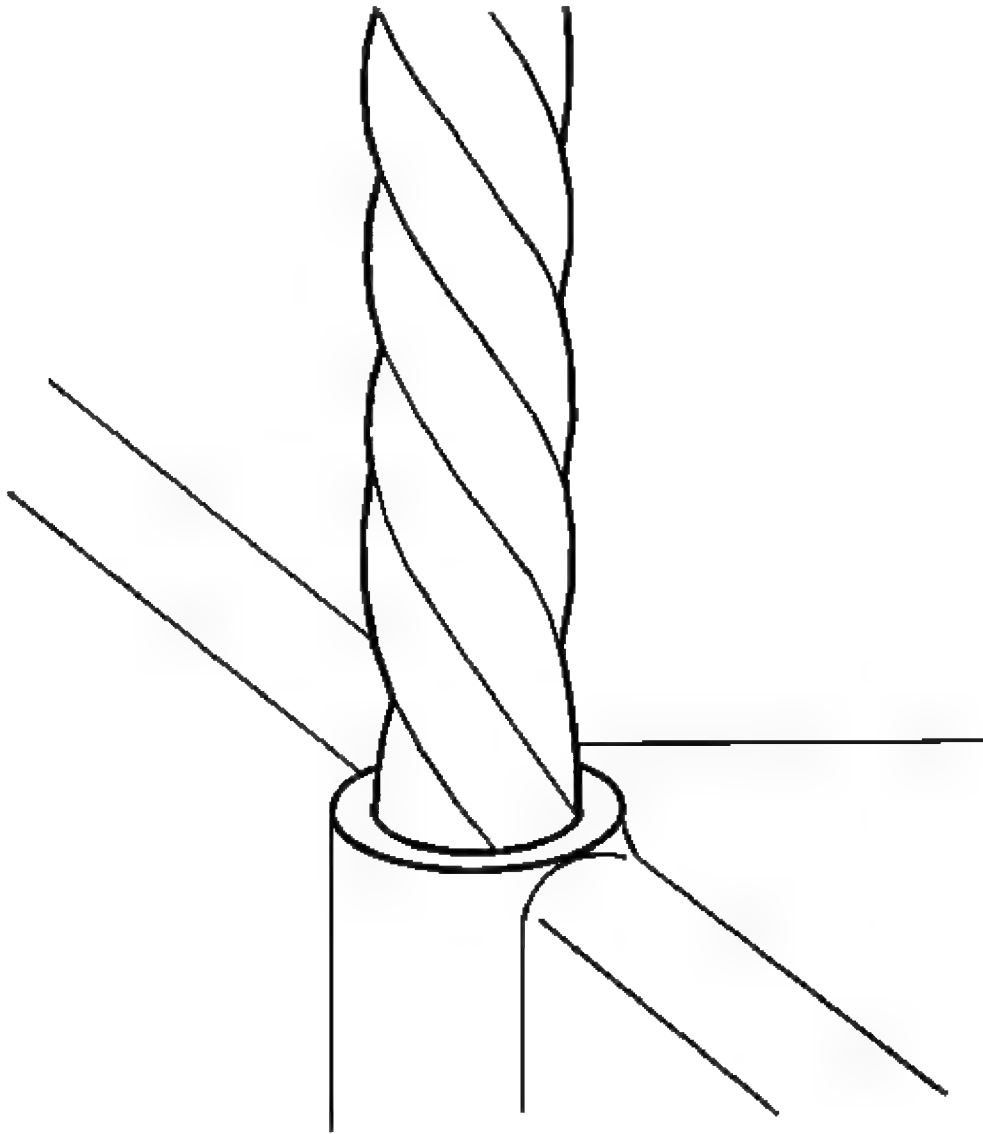


Fig. 169: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- DO NOT drill any further than the original hole depth.

1. Drill out the threads of the damaged hole.

- M6 inserts require a minimum drill depth of 15 mm (0.59 in).
- M8 inserts require a minimum drill depth of 20 mm (0.79 in).
- M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

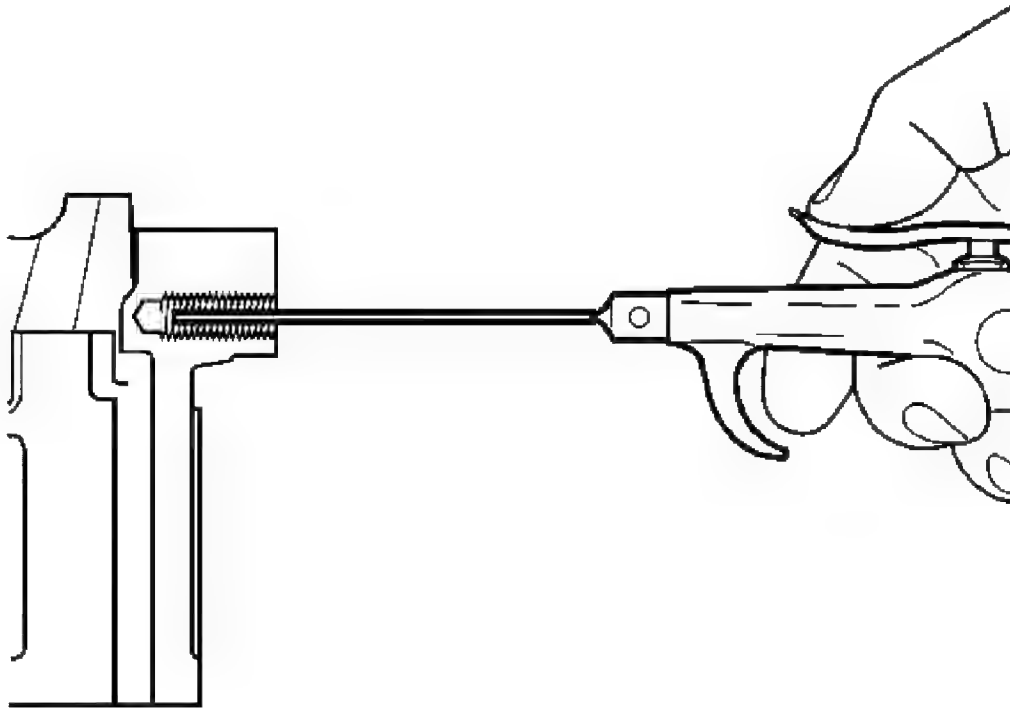


Fig. 170: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

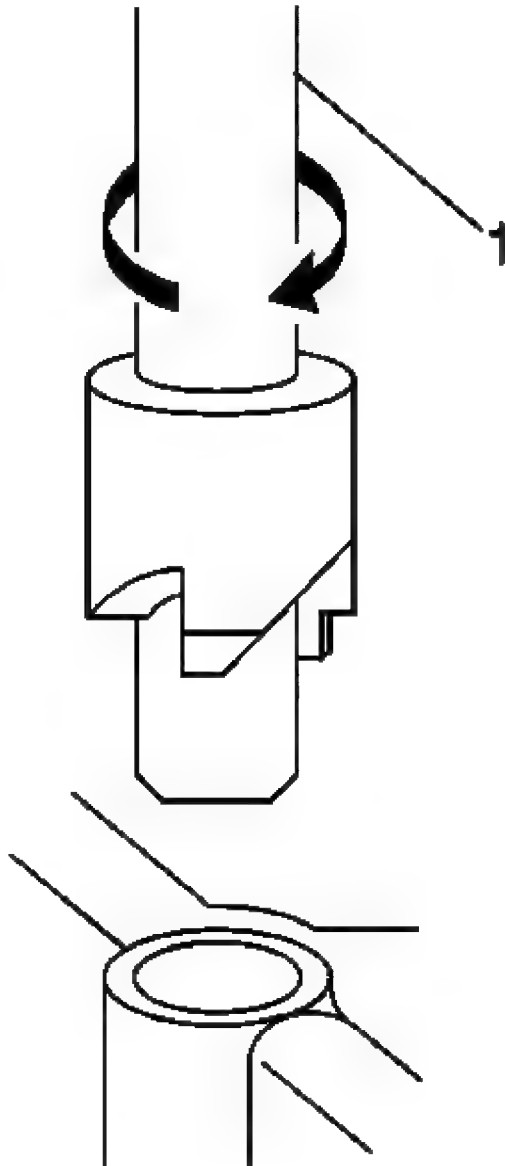


Fig. 171: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A properly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

3. Counterbore the drilled hole to the full depth permitted by the tool (1).

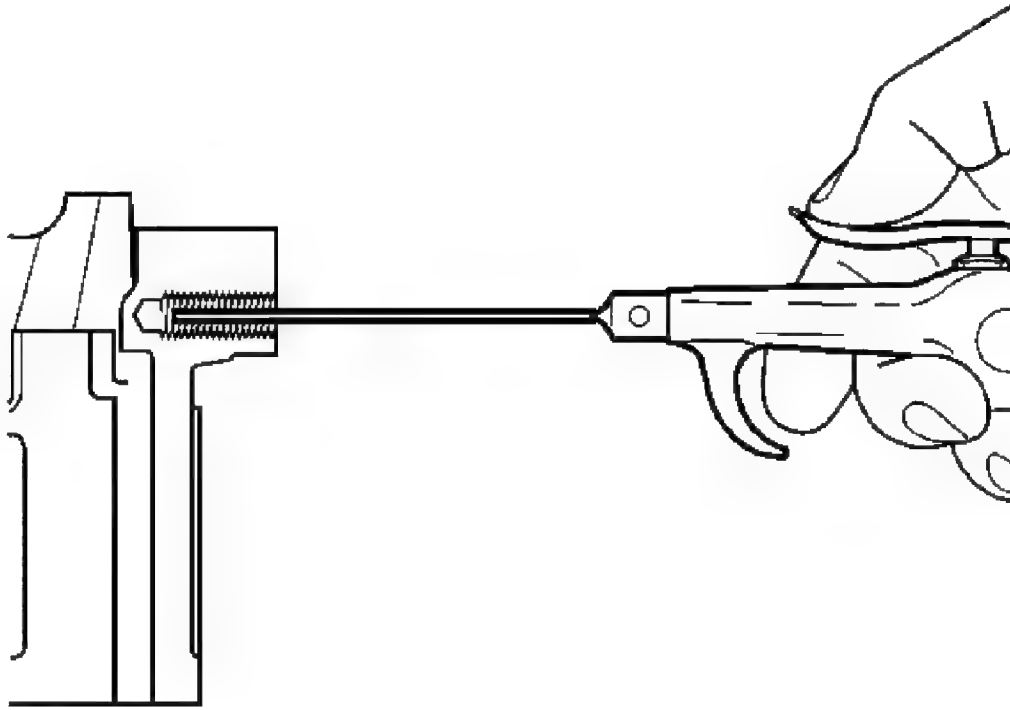


Fig. 172: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

4. Using compressed air, clean out any chips.

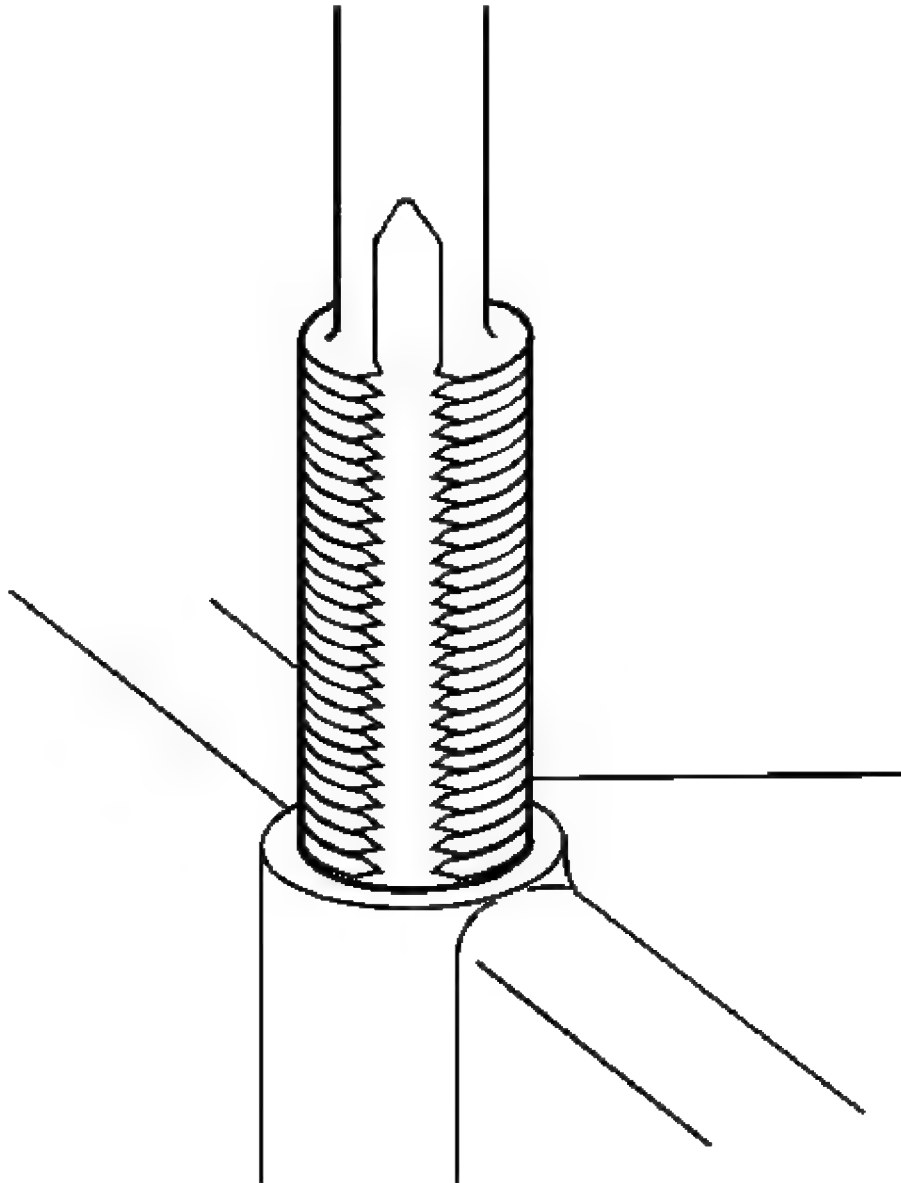


Fig. 173: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the

depth equal to the insert length.

5. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.
 - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
 - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
 - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

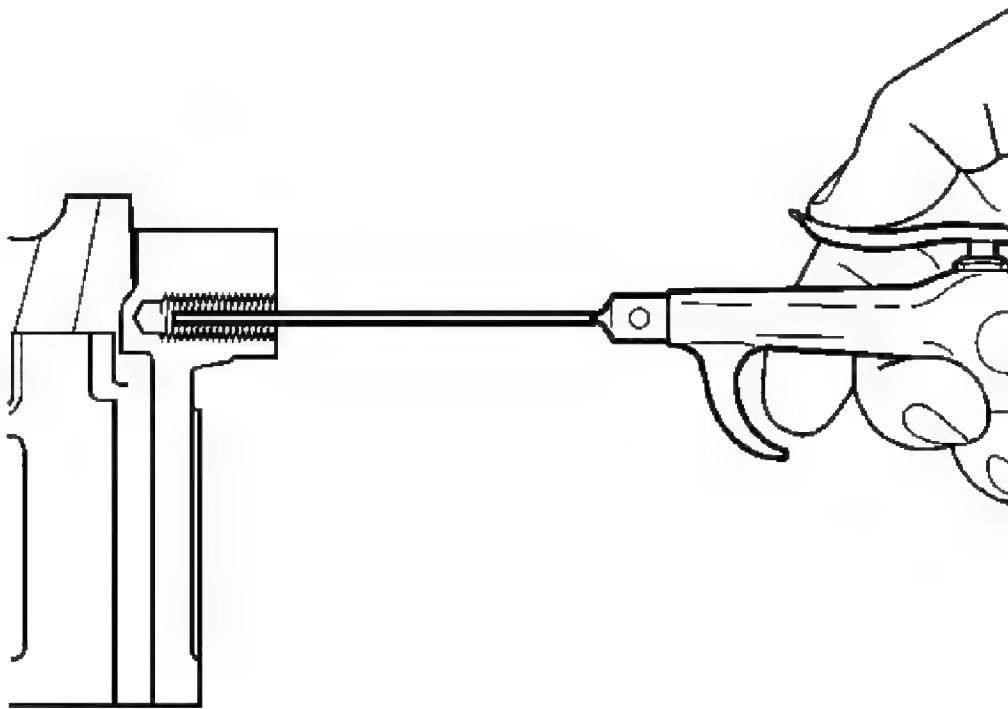


Fig. 174: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

6. Using compressed air, clean out any chips.

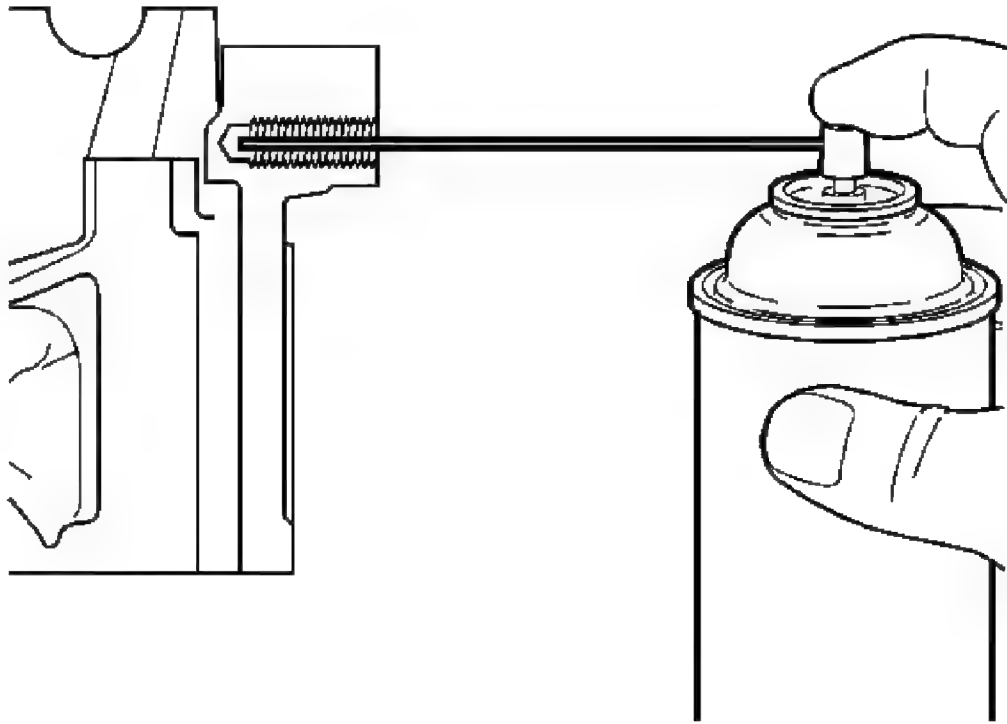


Fig. 175: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

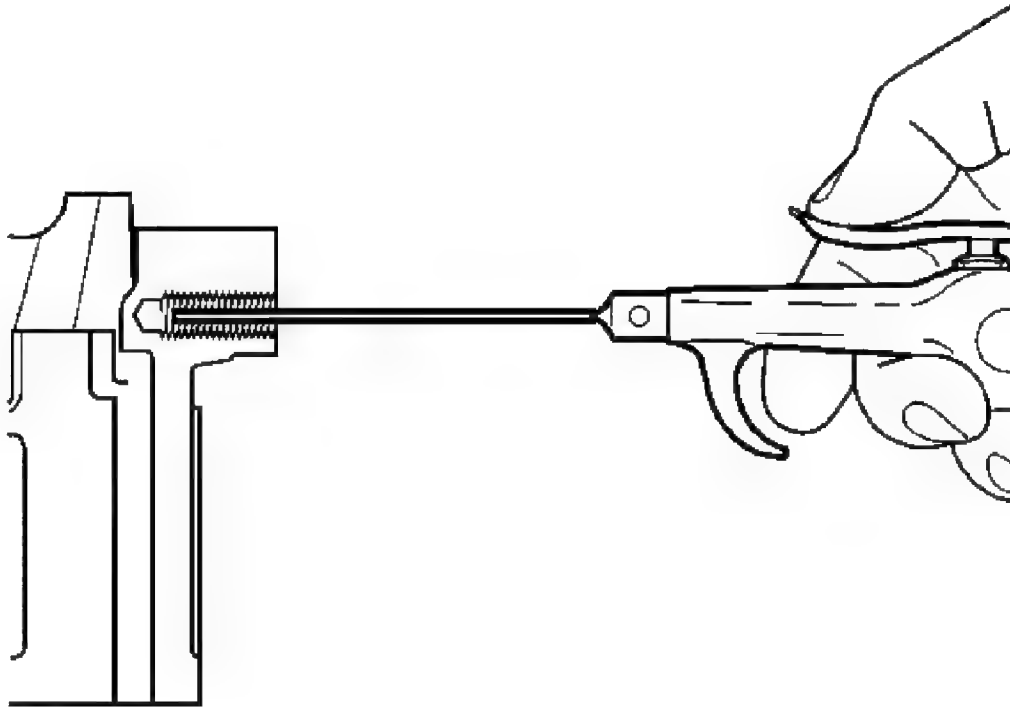


Fig. 176: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.

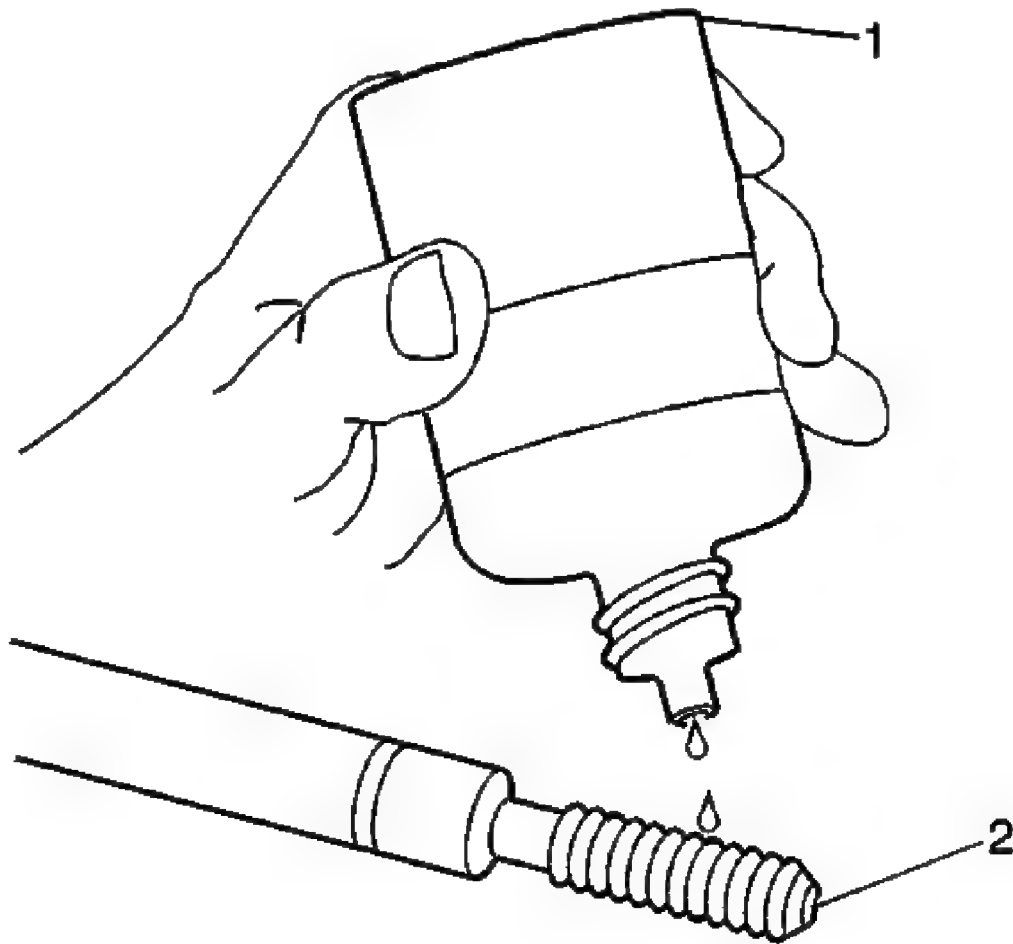


Fig. 177: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

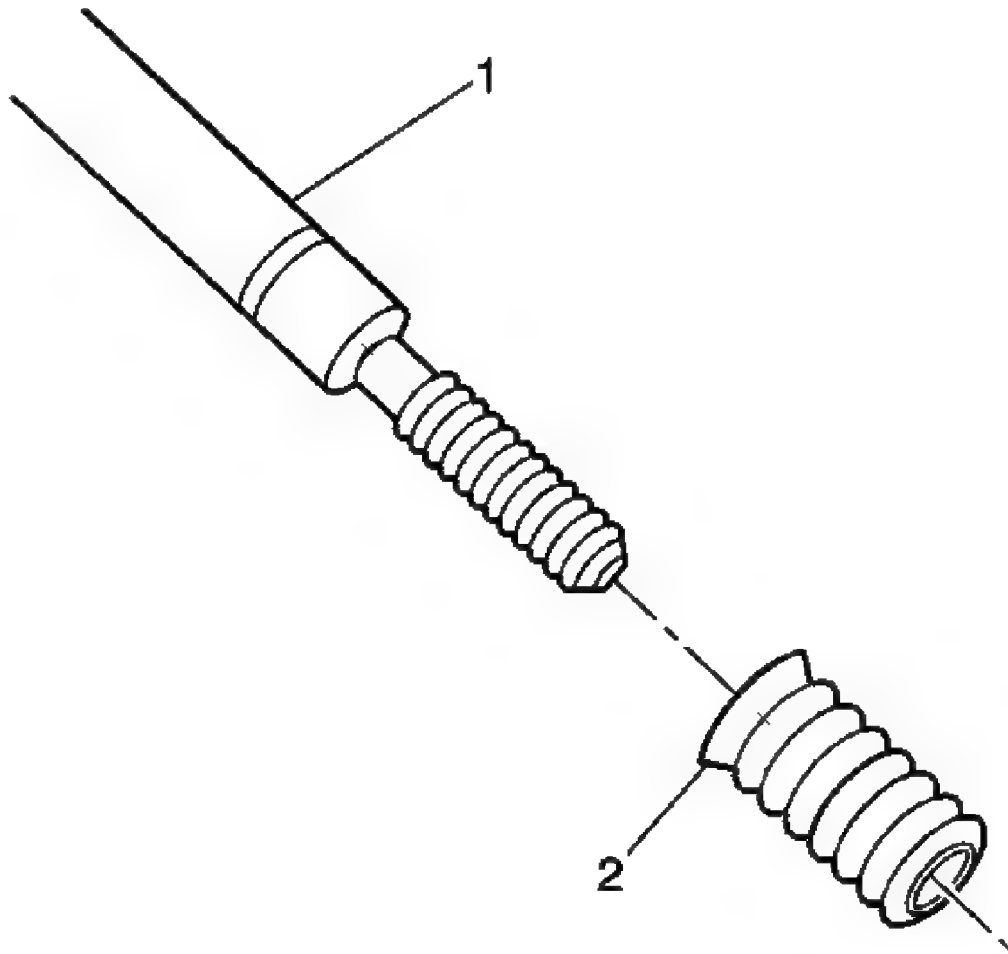


Fig. 178: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver installation tool (1).

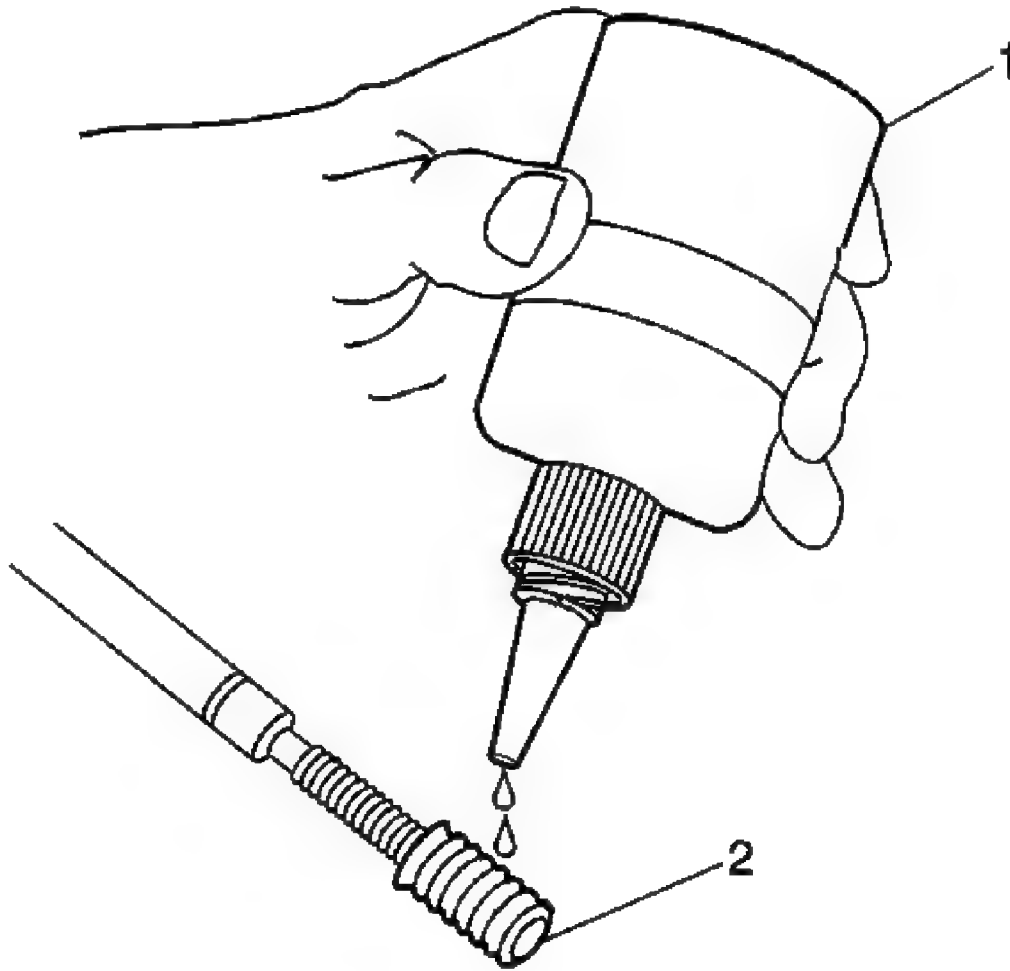


Fig. 179: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

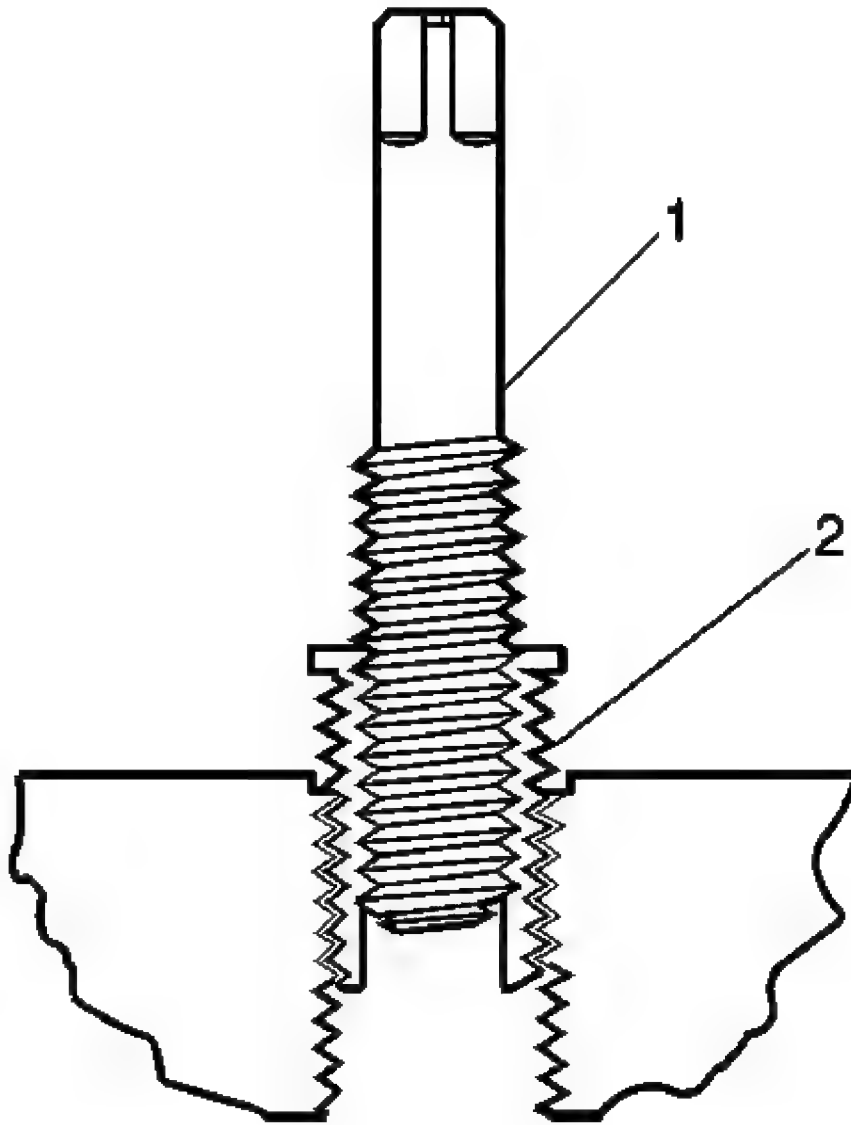


Fig. 180: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the tapped hole by hand only.

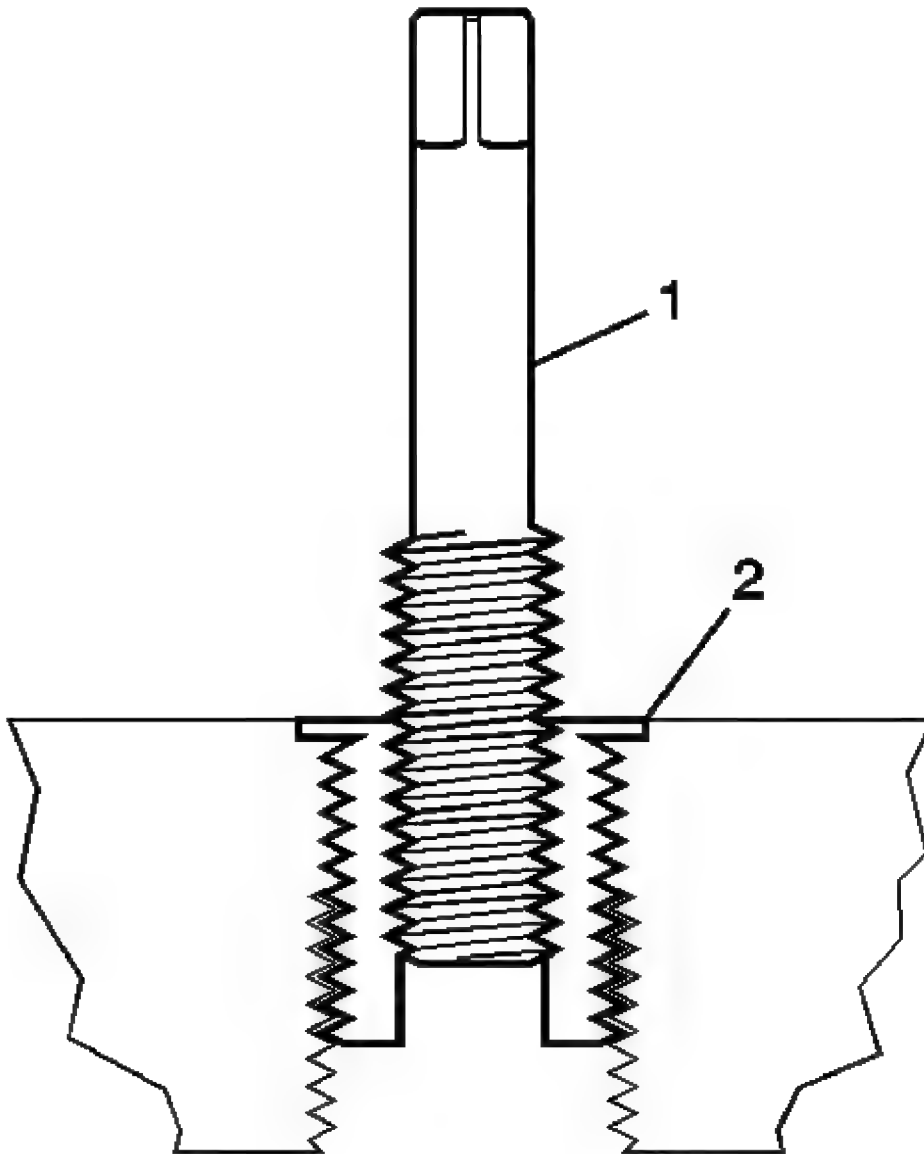


Fig. 181: Installing Insert - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface, remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

13. Install the insert until the flange (2) of the insert contacts the counterbored surface.

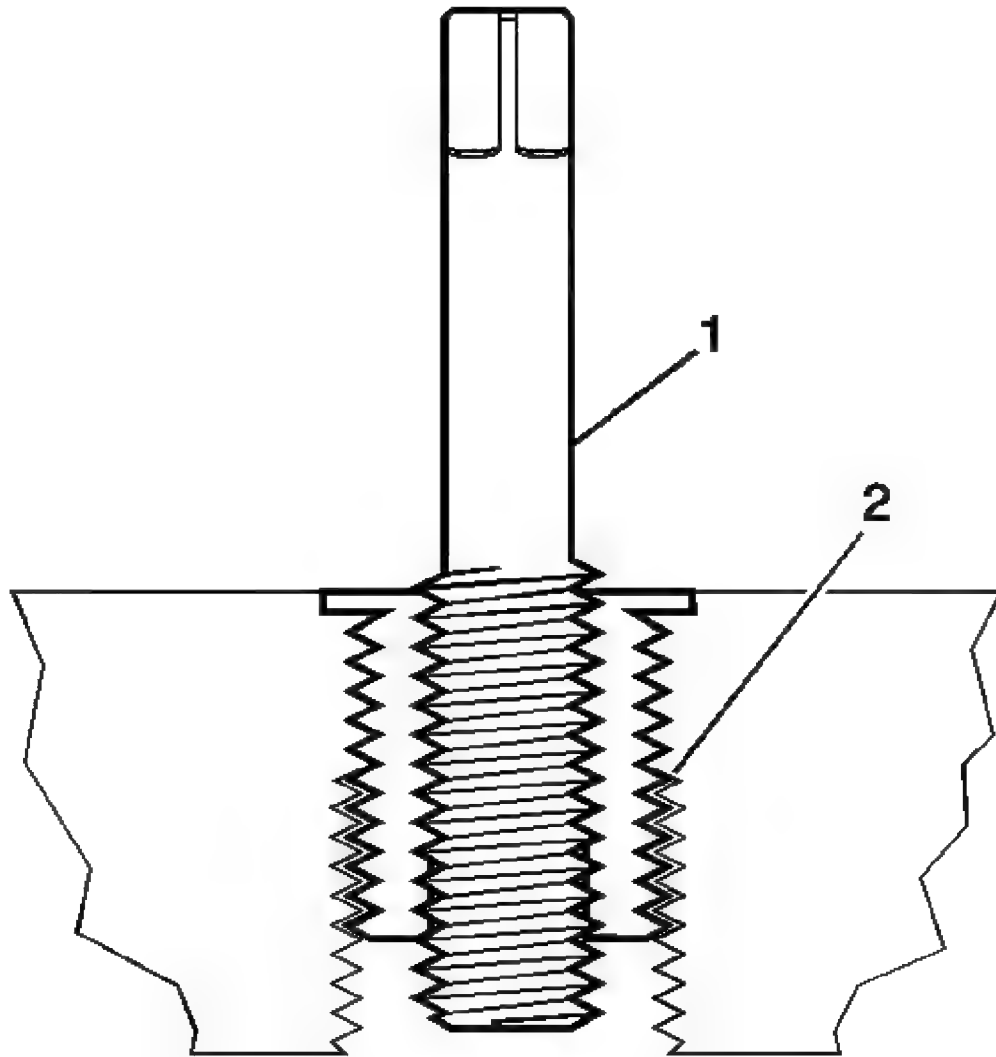


Fig. 182: View Insert And Tool - Standard Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

14. Continue to rotate the driver installation tool (1) through the insert (2).

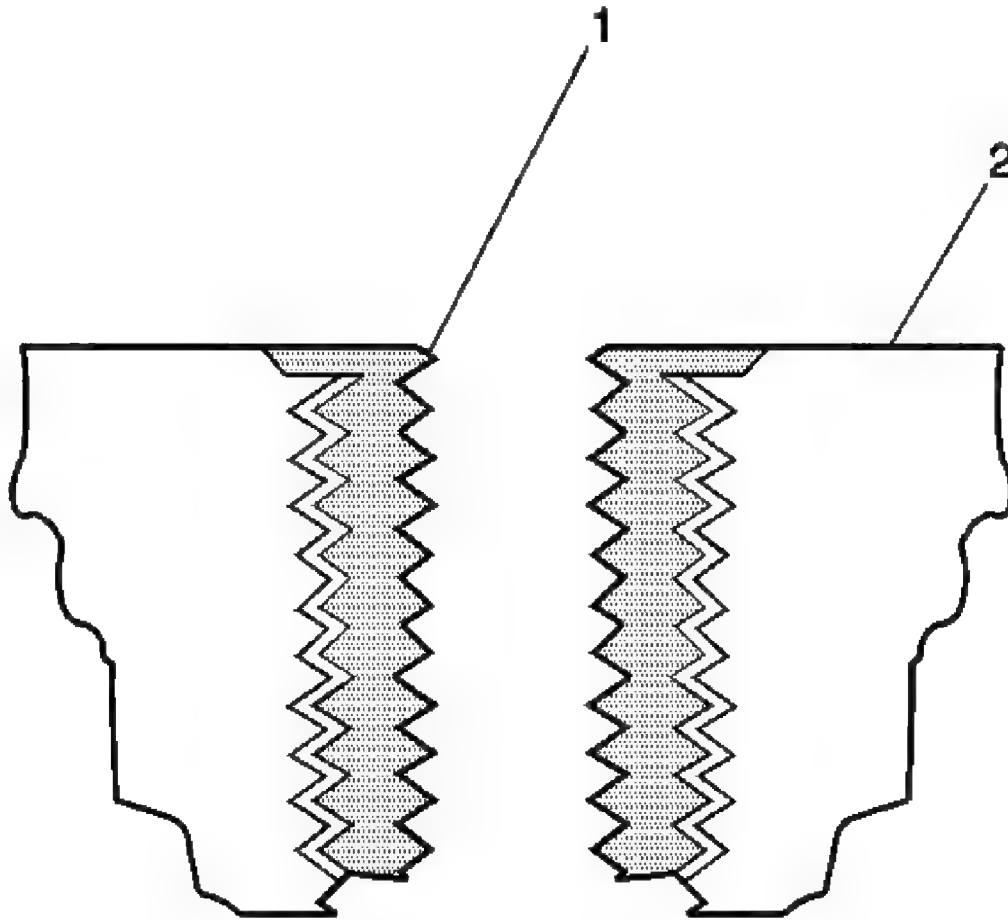


Fig. 183: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

15. Inspect the insert for proper installation into the tapped hole. A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

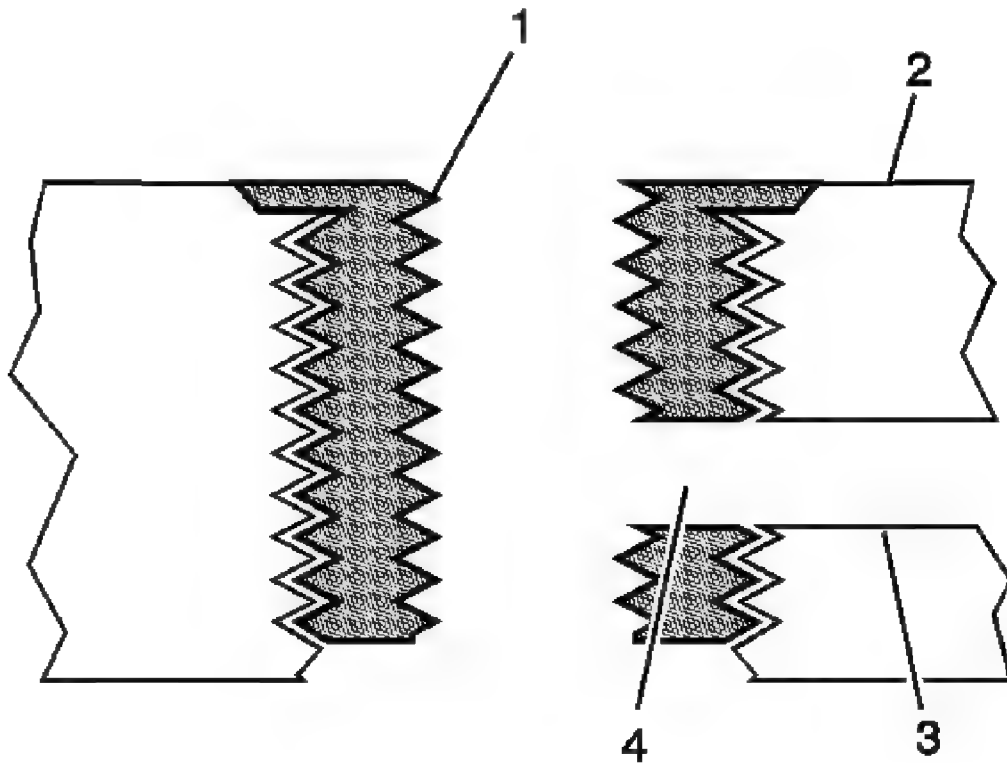


Fig. 184: View Of Restricted Engine Coolant Passages - Standard Thread Repair
Courtesy of GENERAL MOTORS CORP.

16. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

RECESSED THREAD REPAIR

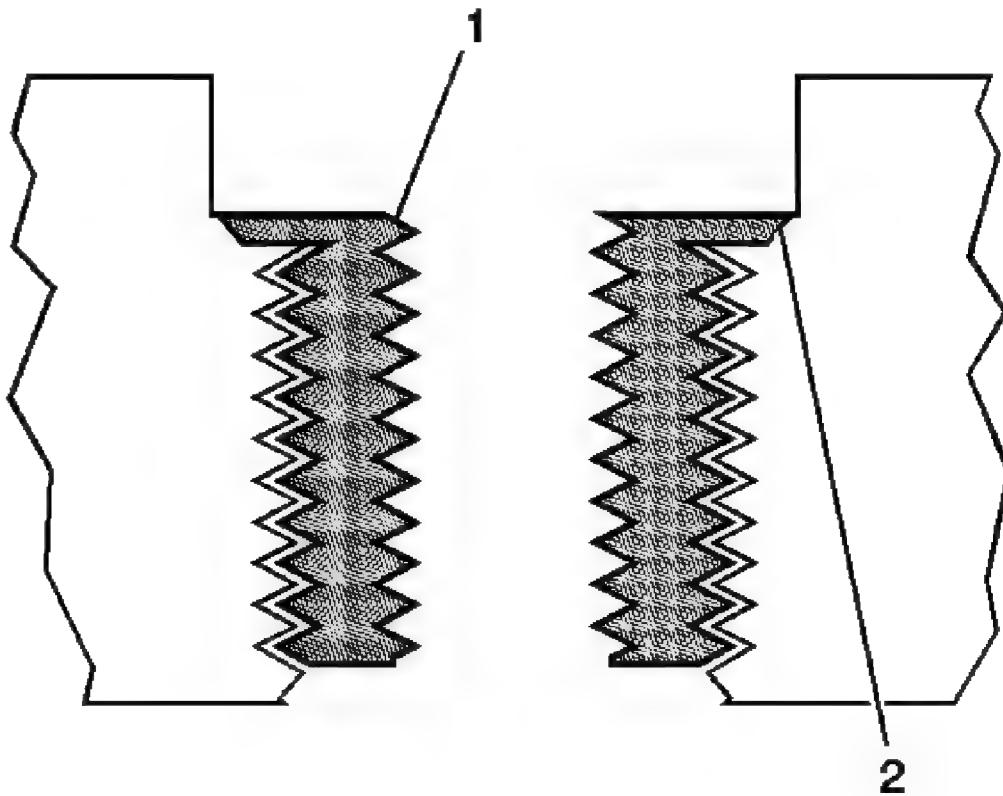


Fig. 185: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.
- Do NOT remove the original stop collar from a counterbore drill.

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.

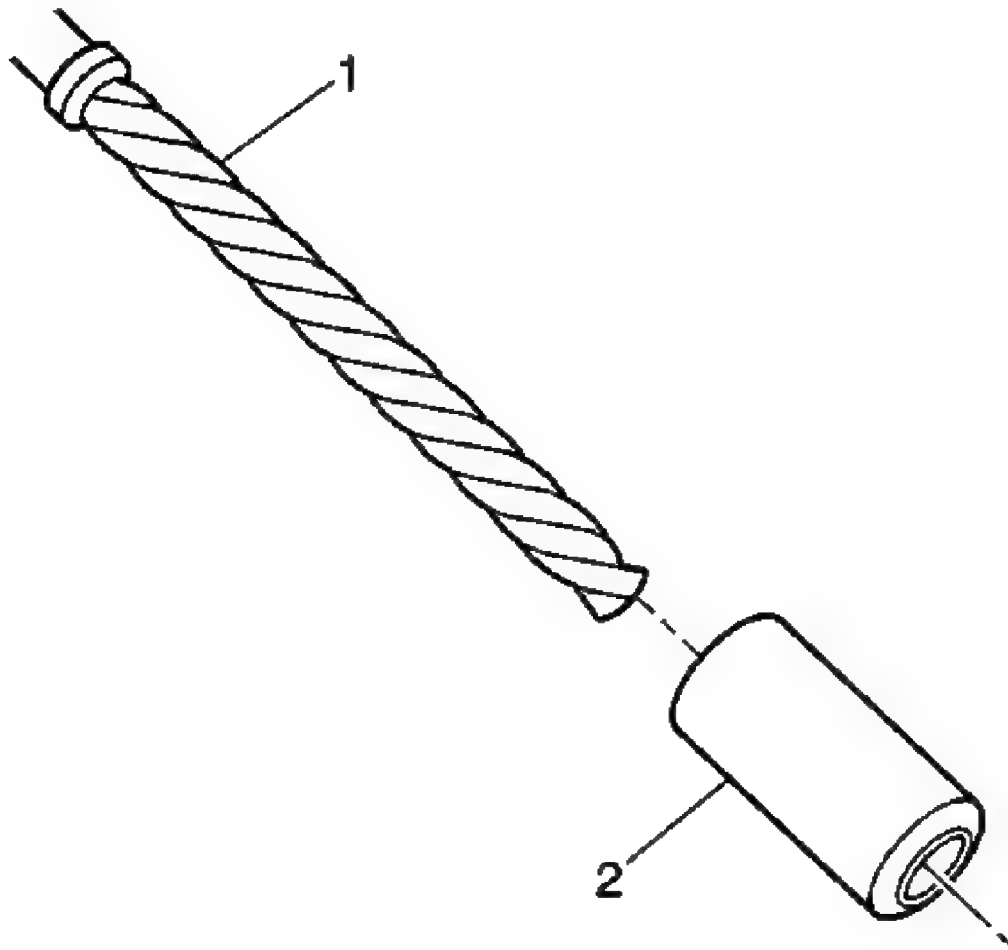


Fig. 186: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

1. Install a stop collar (2) on the counterbore drill (1), if required.

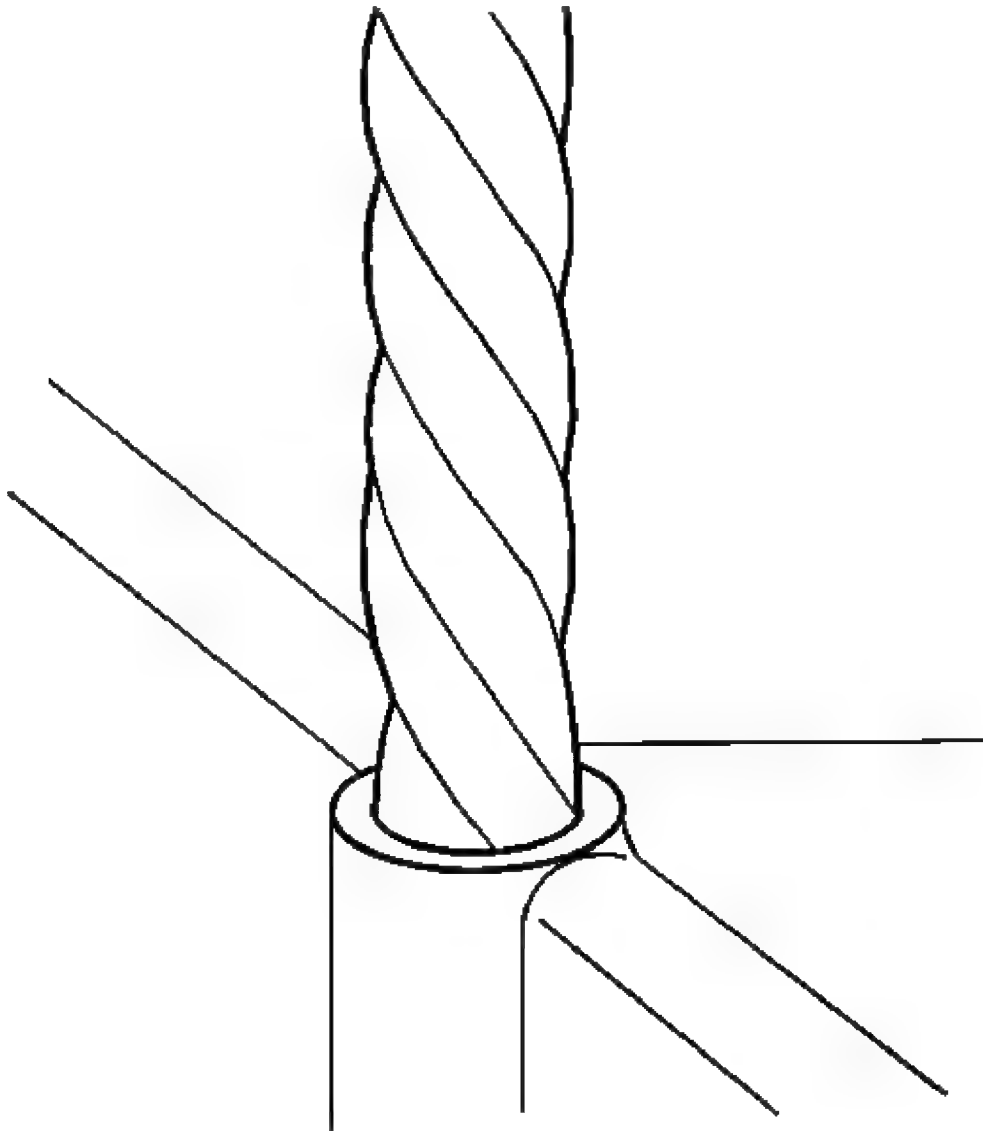


Fig. 187: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

2. Drill out the threads of the damaged hole.

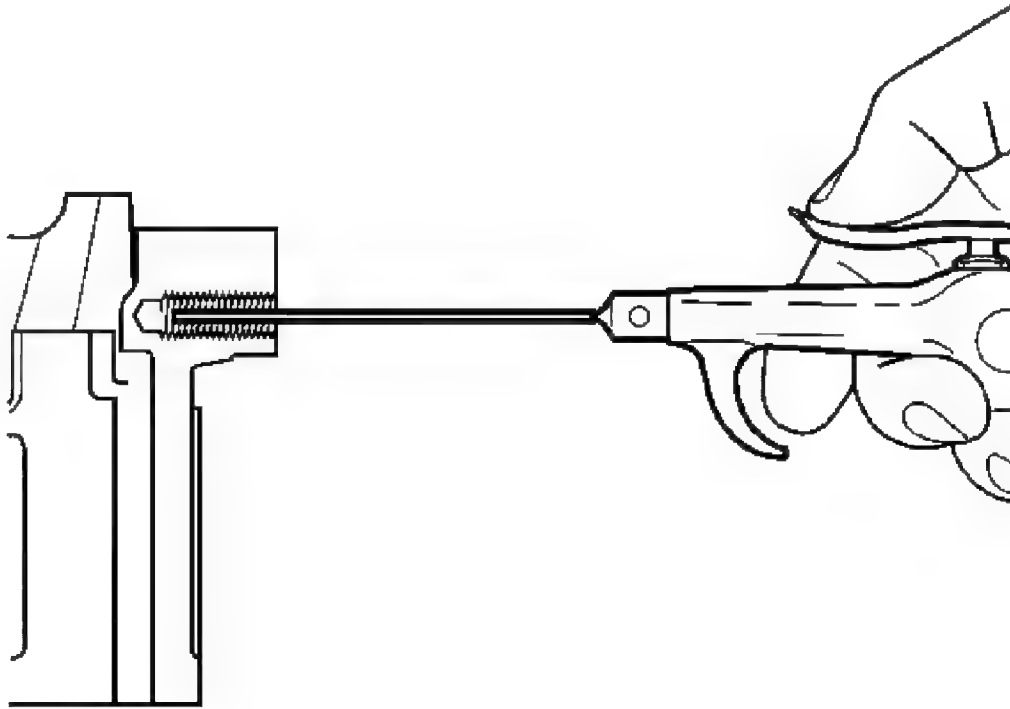


Fig. 188: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.

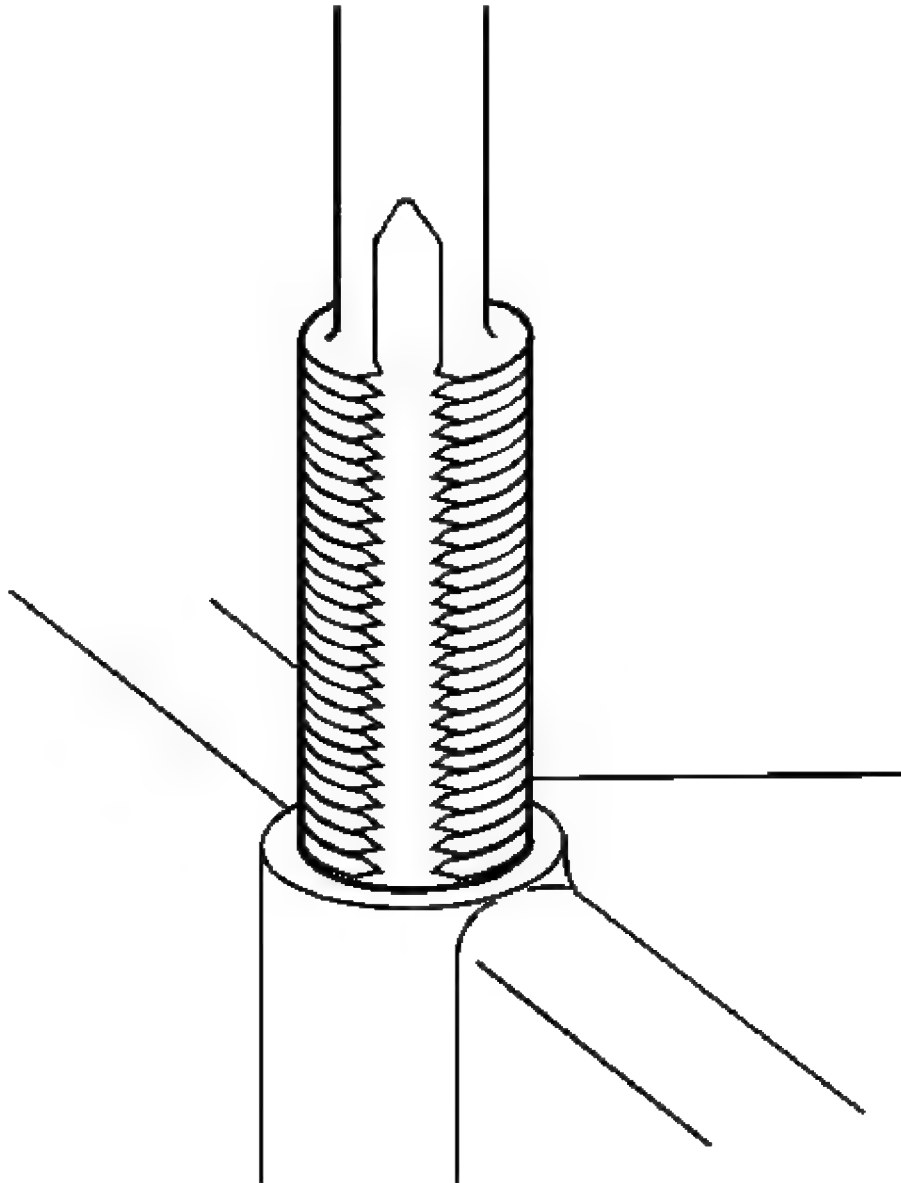


Fig. 189: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the

depth equal to the insert length.

4. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

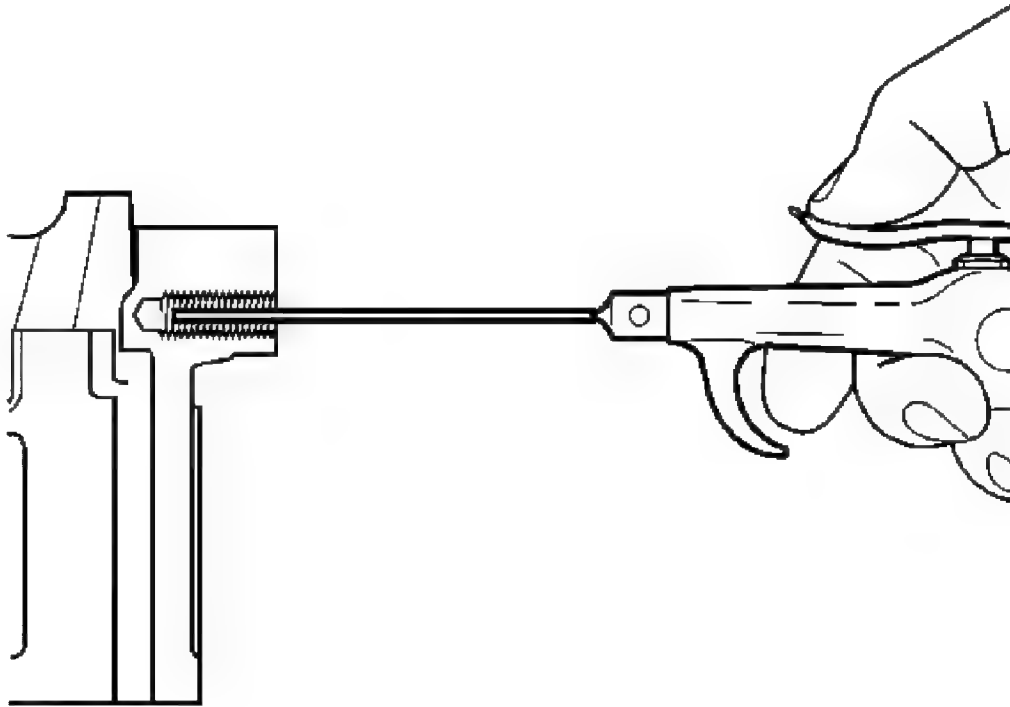


Fig. 190: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

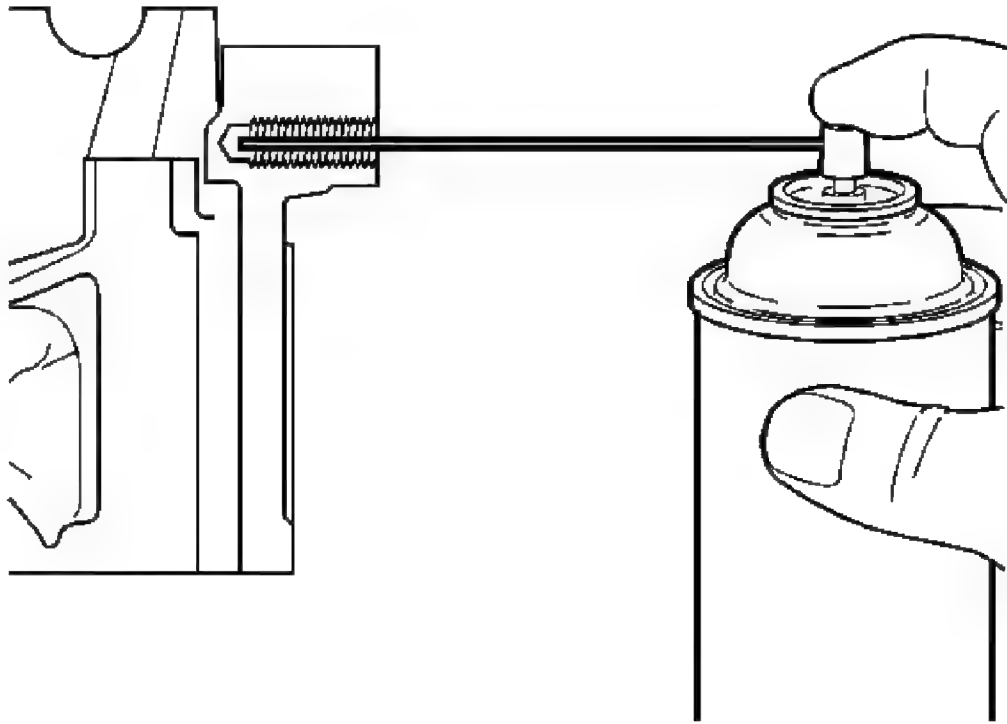


Fig. 191: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

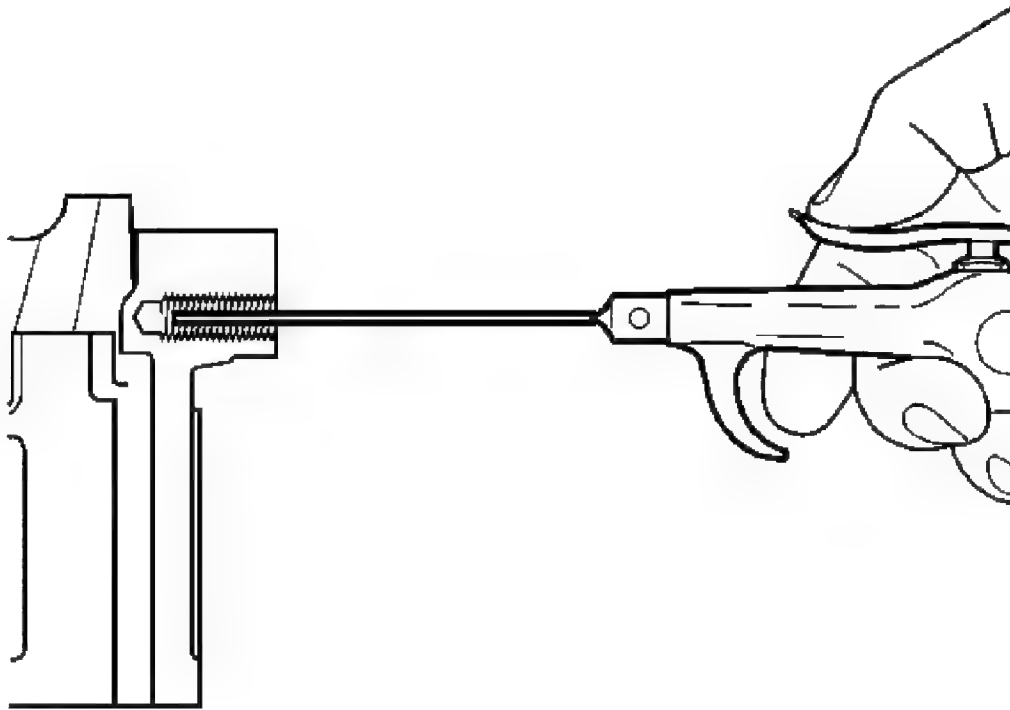


Fig. 192: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

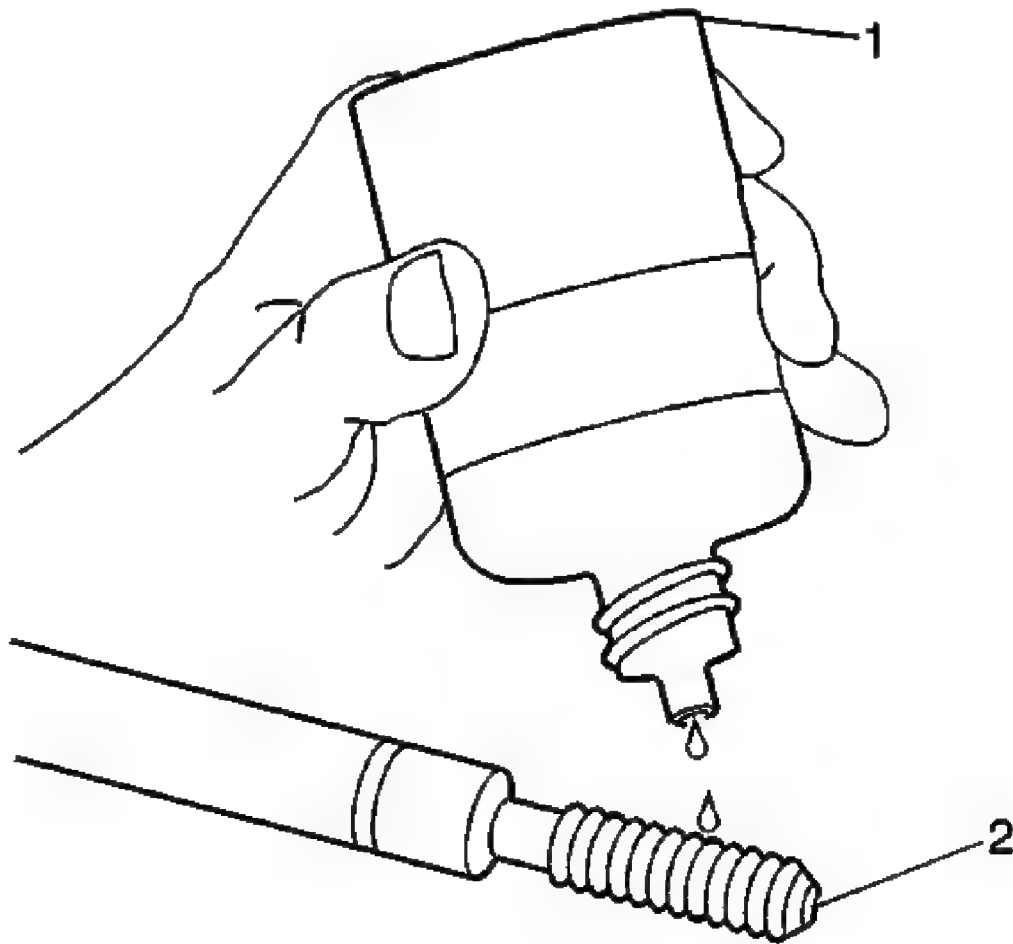


Fig. 193: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

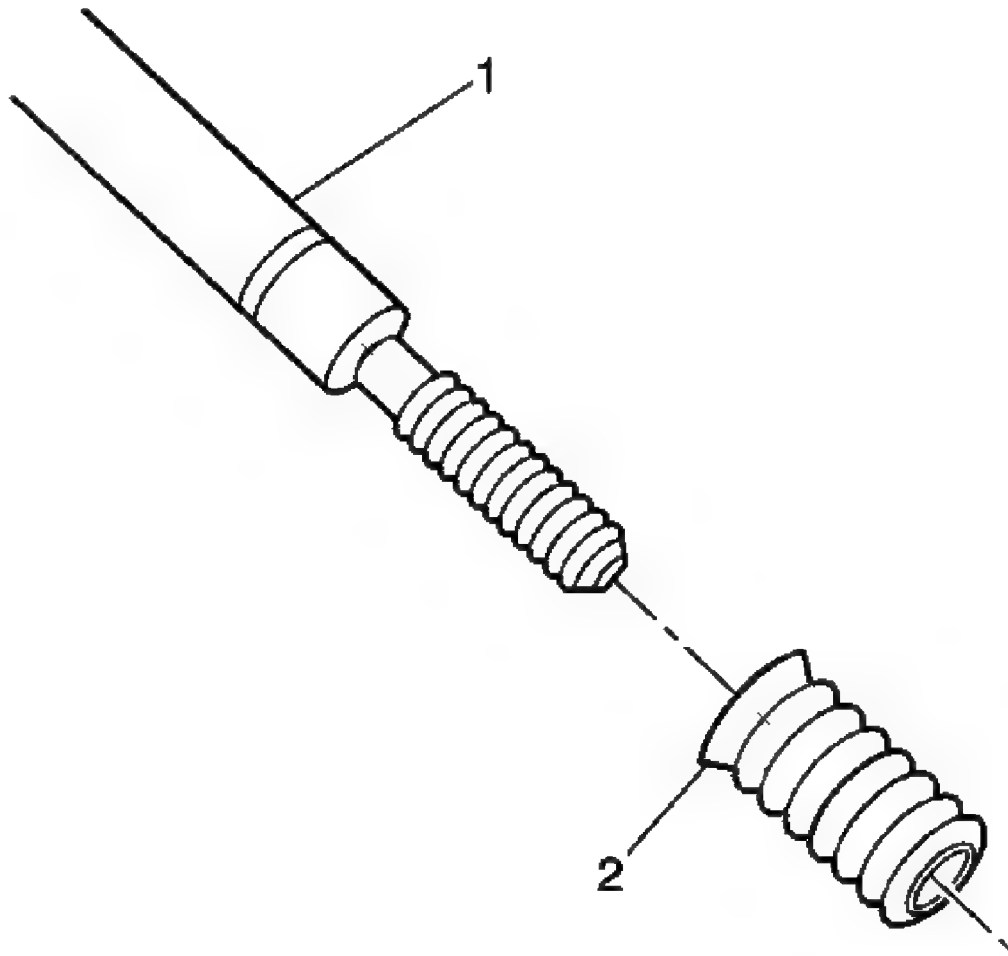


Fig. 194: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).

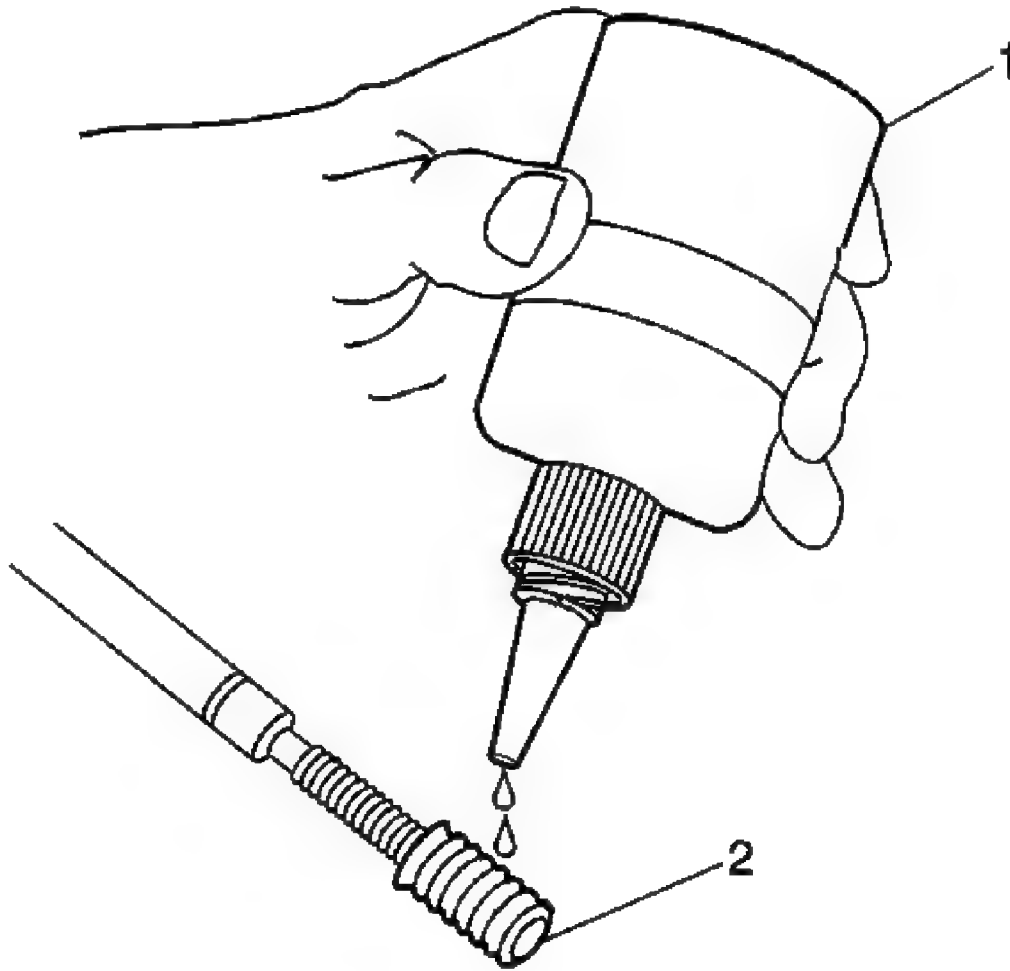


Fig. 195: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

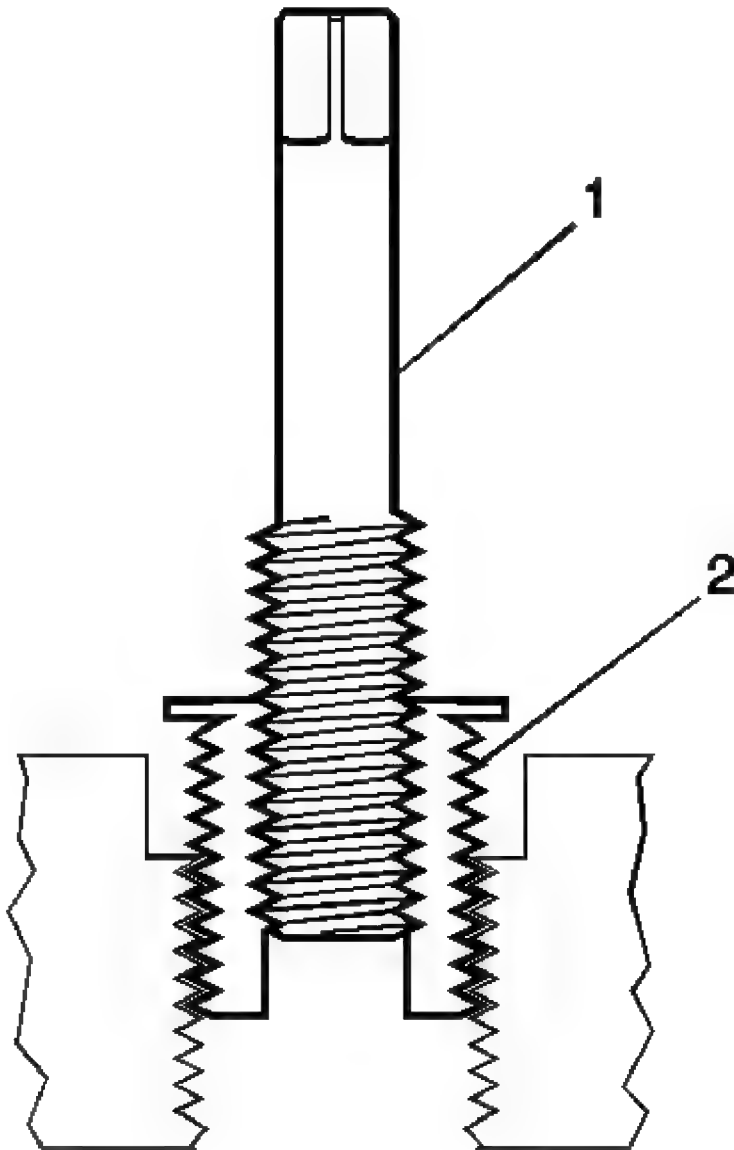


Fig. 196: Installing Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole by hand only.

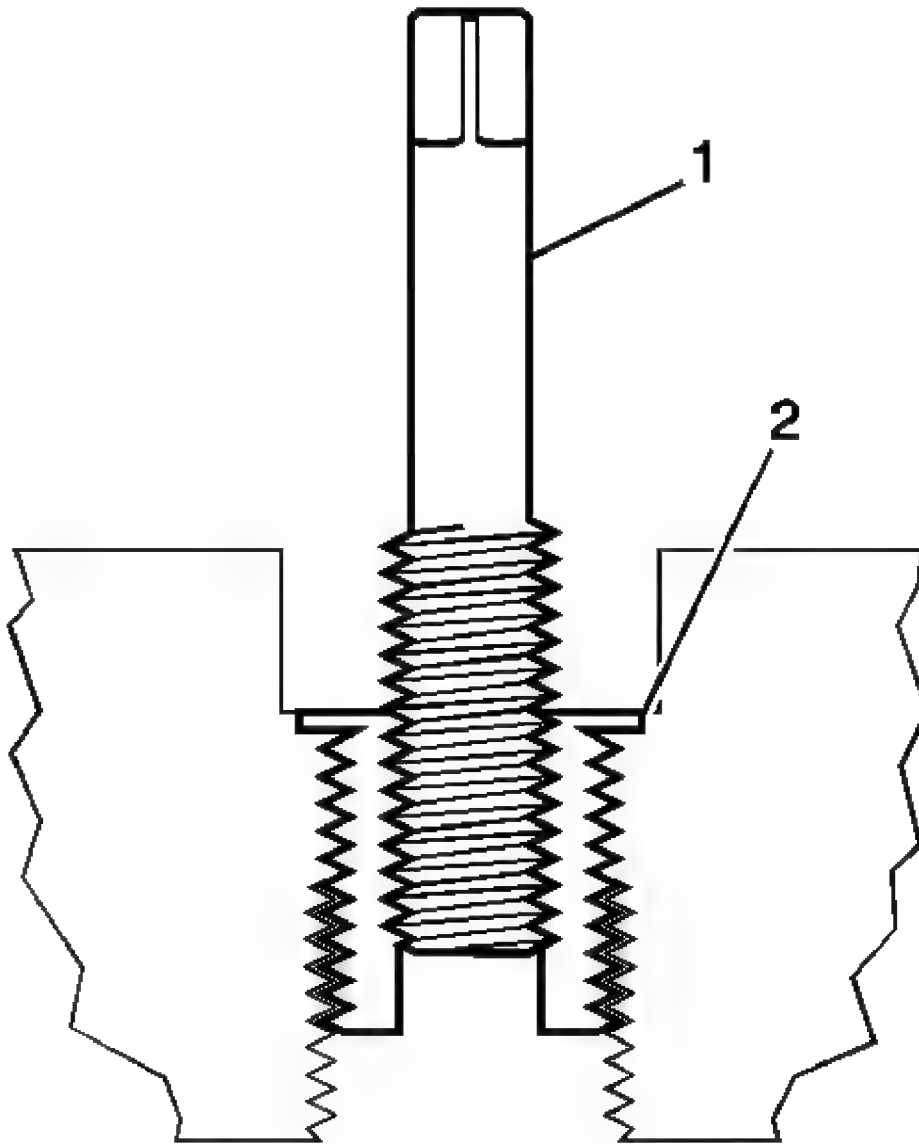


Fig. 197: View Of Installed Insert - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

12. Install the insert until the flange (2) of the insert contacts the counterbored surface.

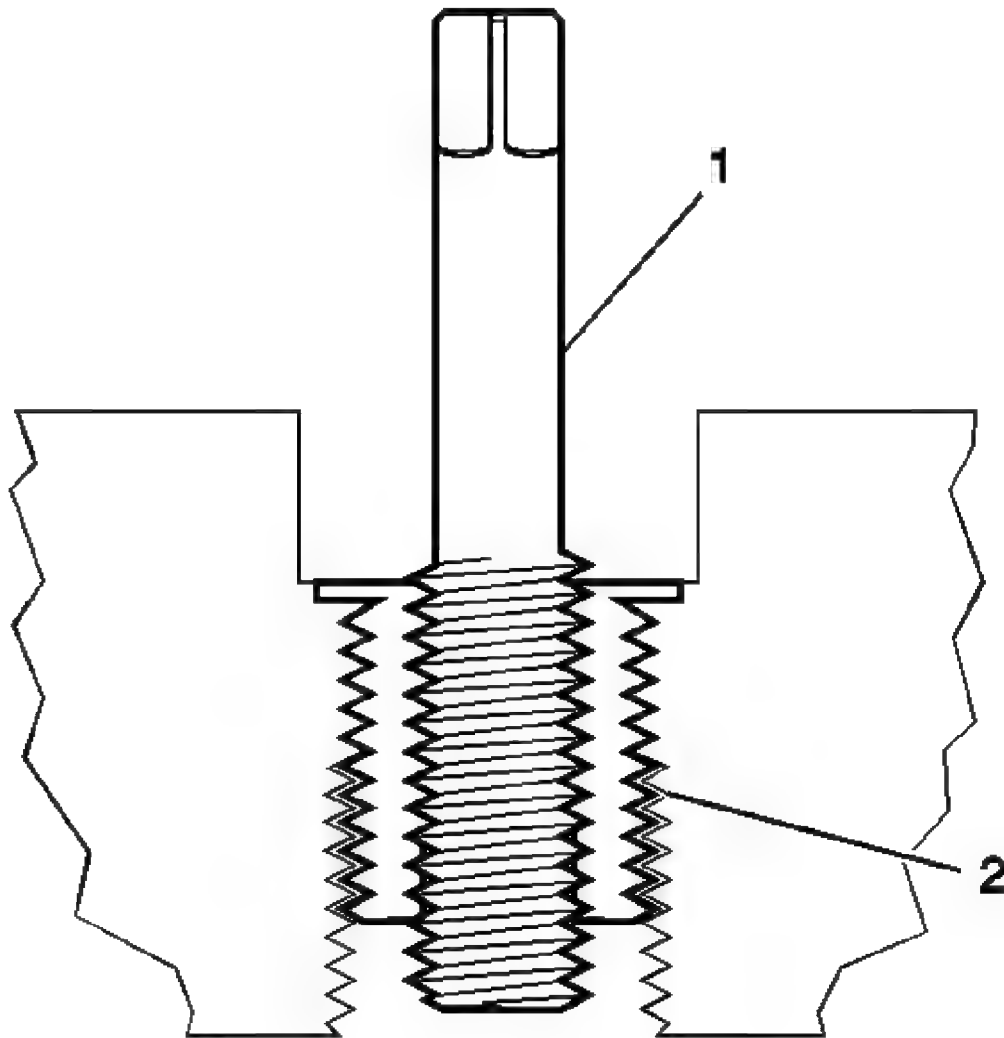


Fig. 198: Installed Insert - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) through the insert (2).

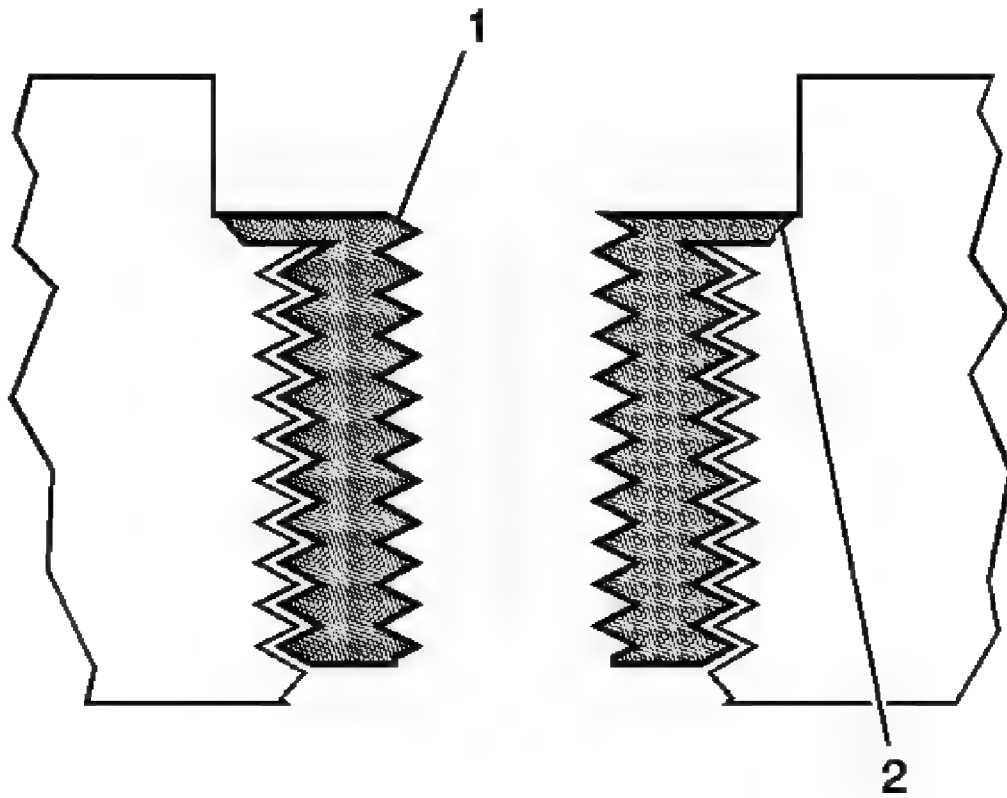


Fig. 199: Inspecting Insert For Proper Installation - Recessed Thread
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

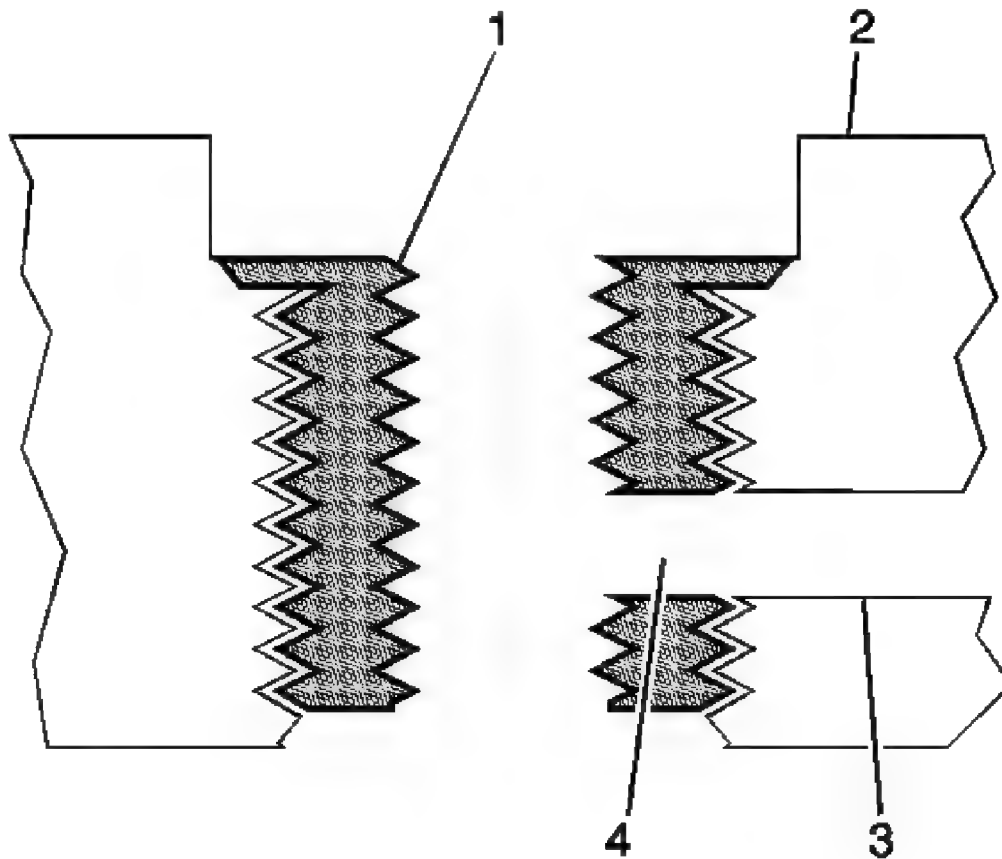


Fig. 200: View Of Restricted Engine Coolant Passage - Recessed Thread Repair
Courtesy of GENERAL MOTORS CORP.

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

TAPERED PIPE THREAD REPAIR

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

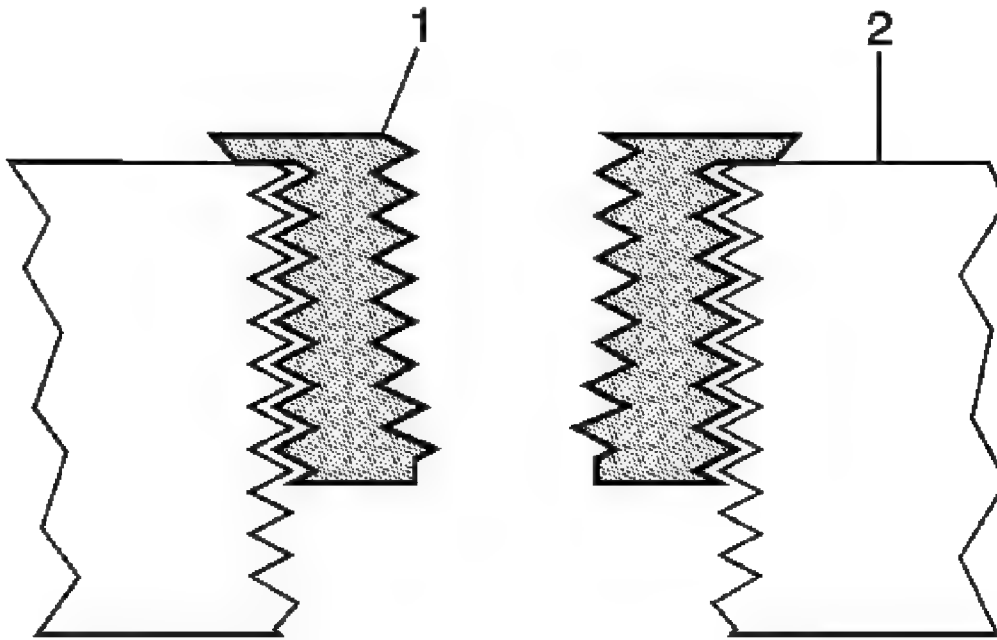


Fig. 201: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

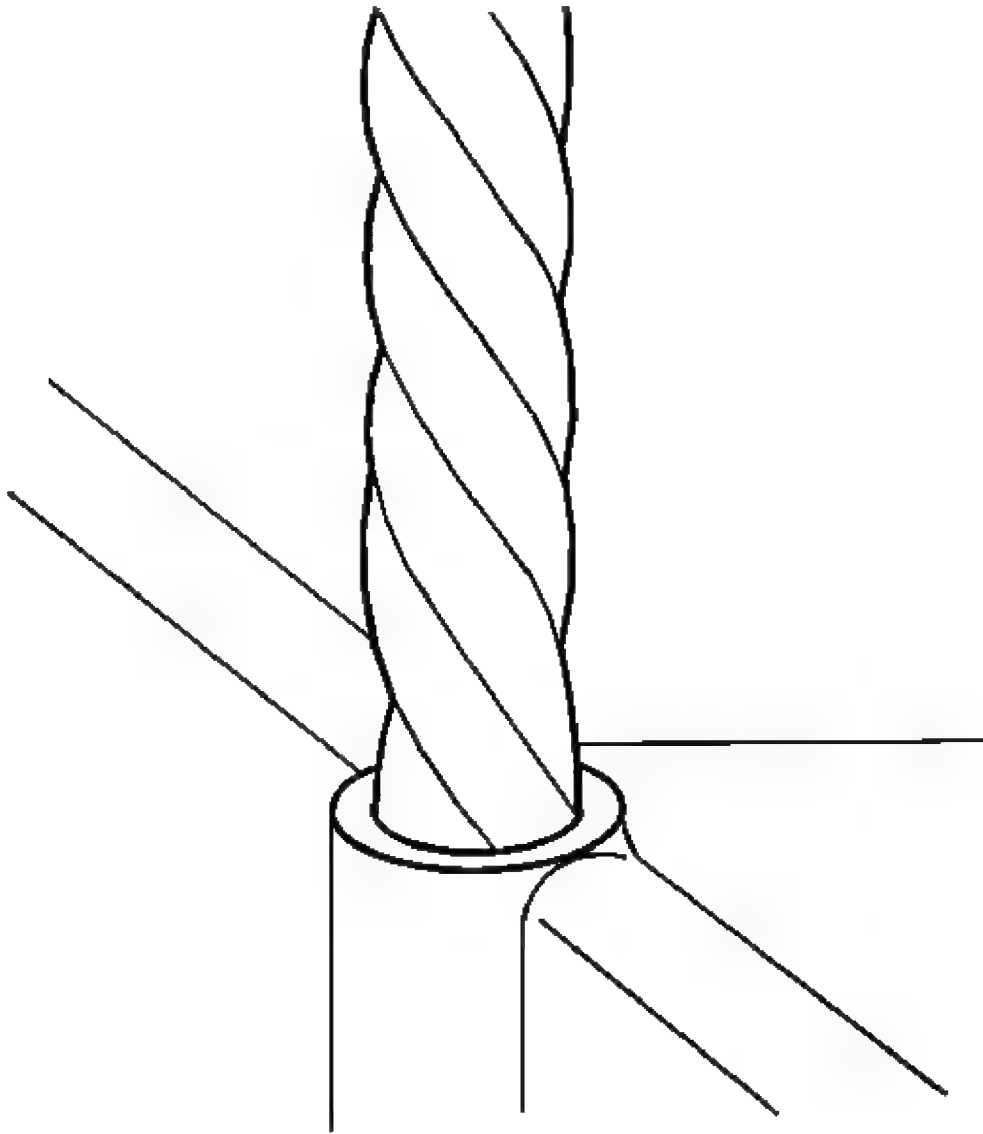


Fig. 202: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

1. Drill out the threads of the damaged hole.

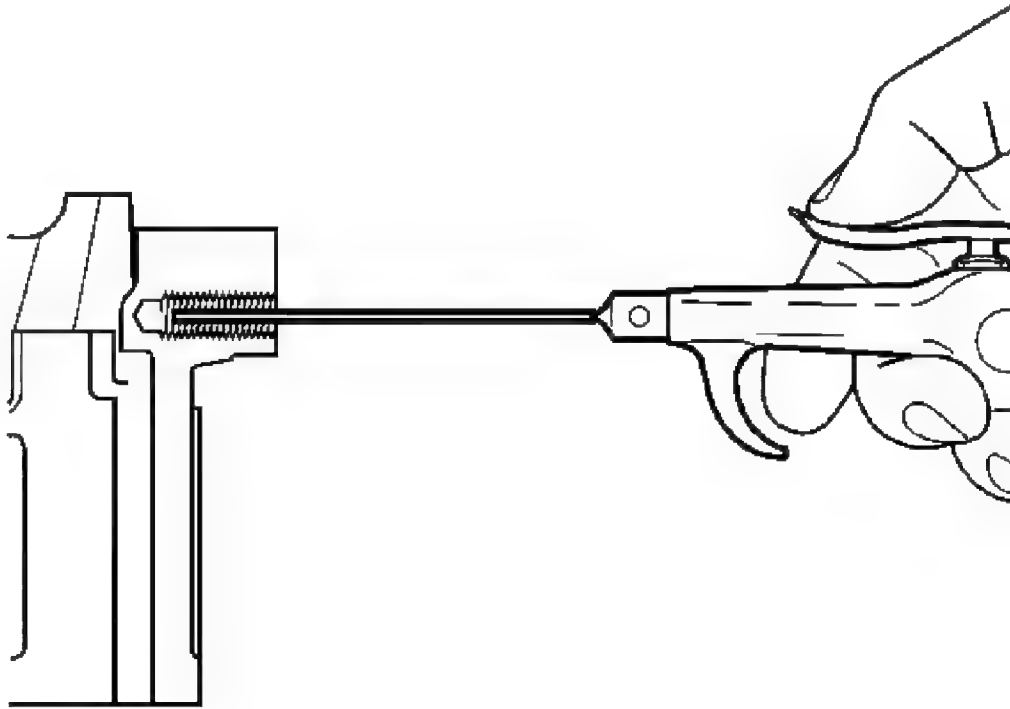


Fig. 203: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

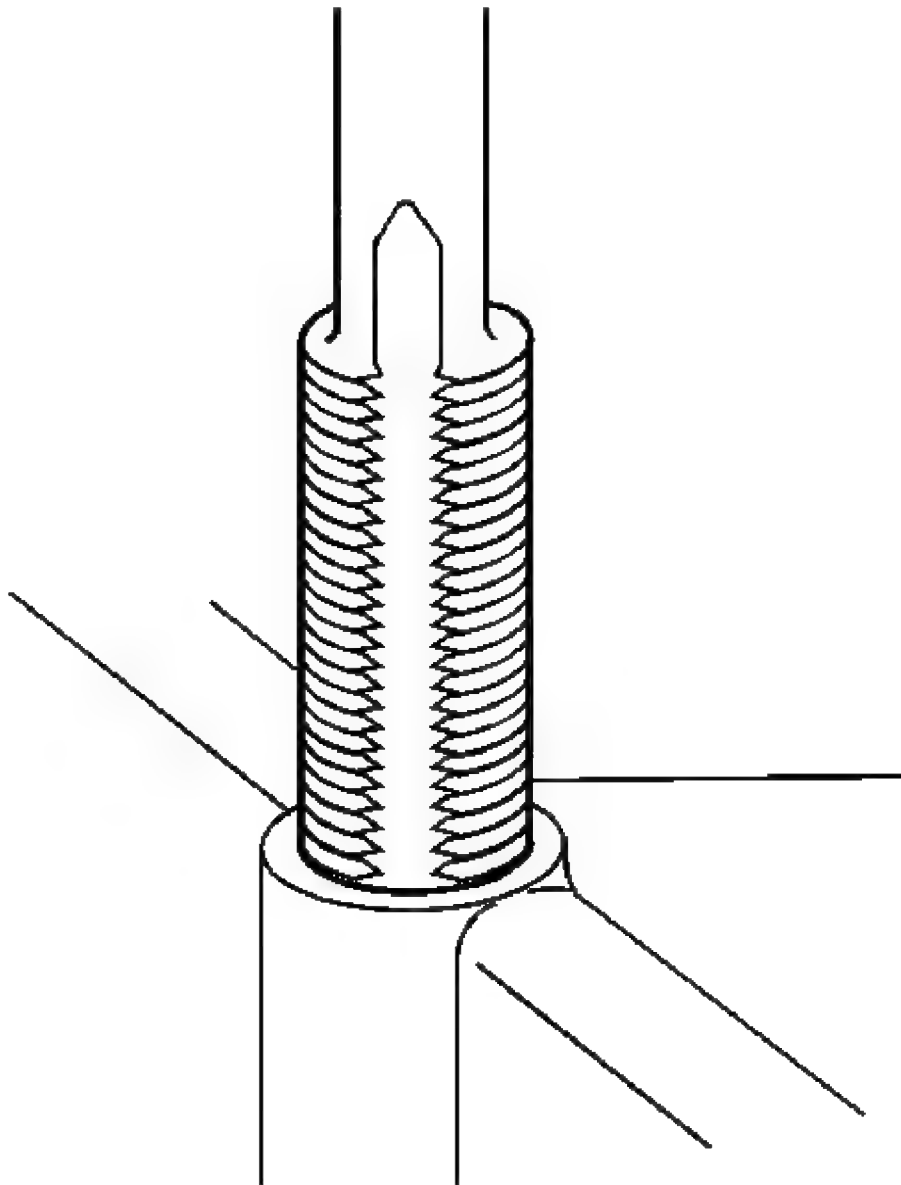


Fig. 204: Tapping Threads Of Drilled Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the

depth equal to the insert length.

3. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

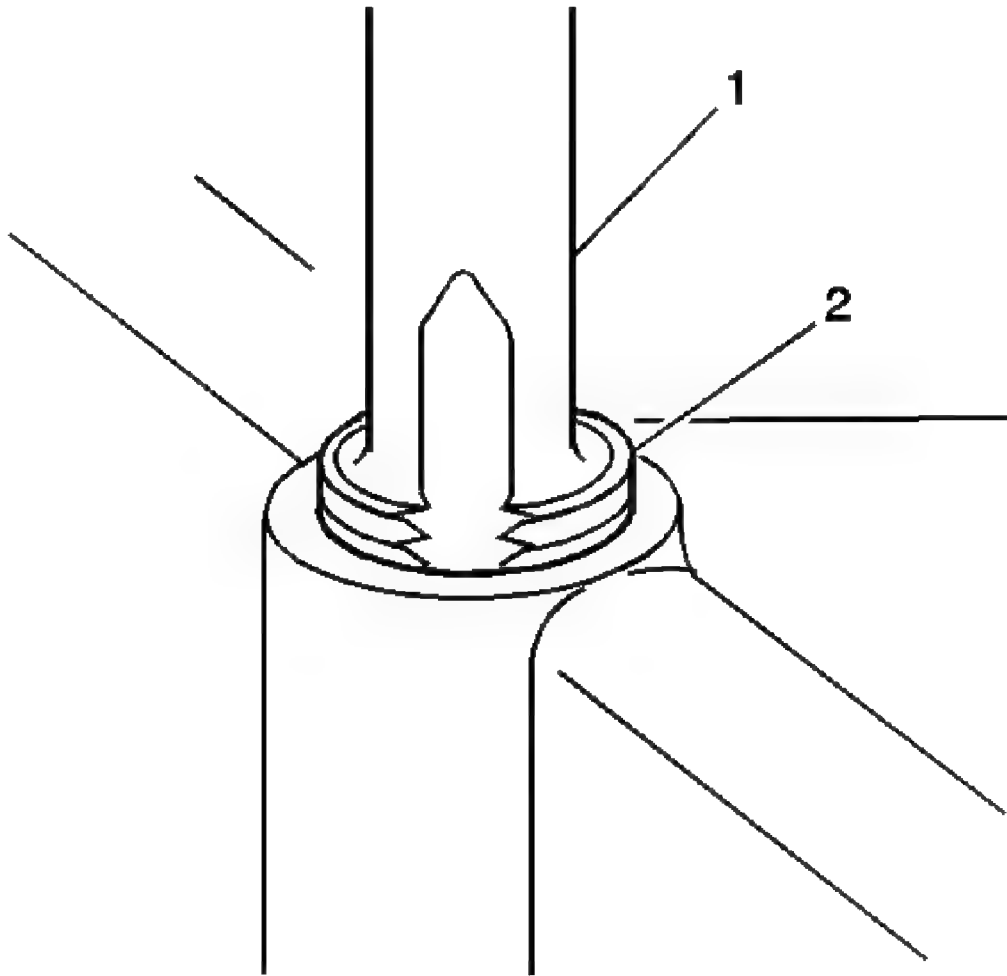


Fig. 205: View Of Proper Tapping Distance - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

4. Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material.

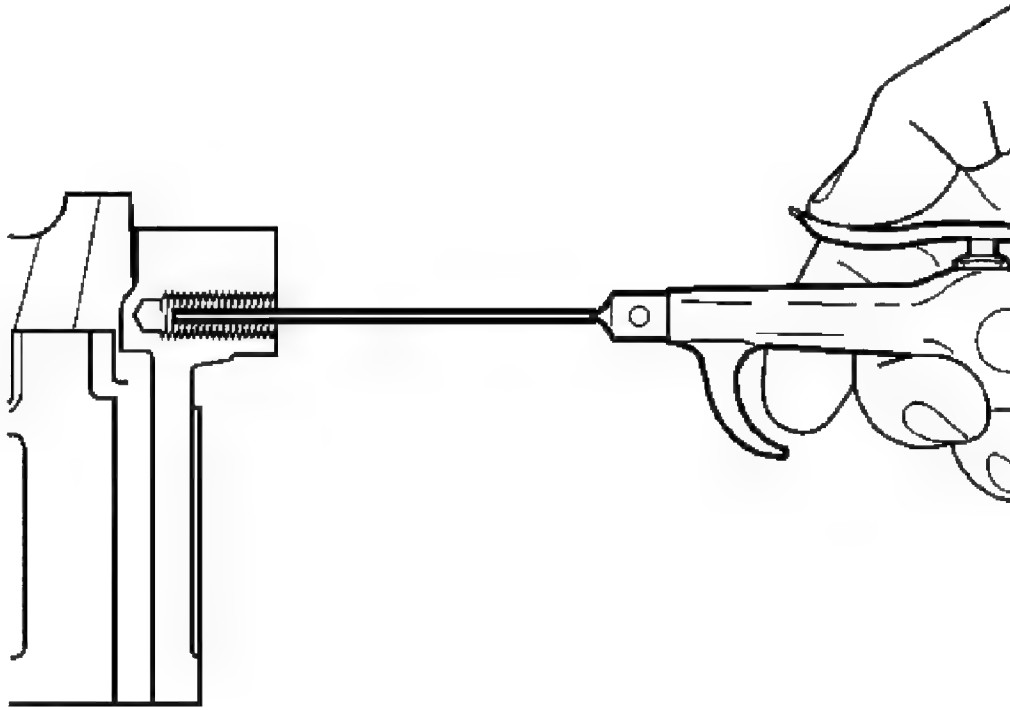


Fig. 206: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

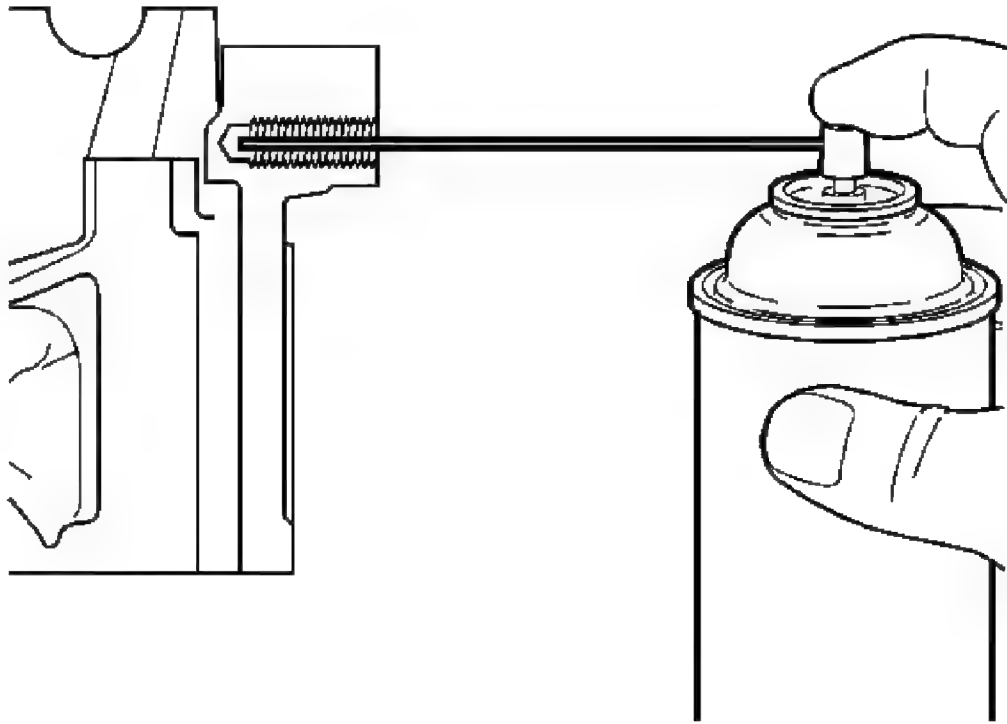


Fig. 207: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

6. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

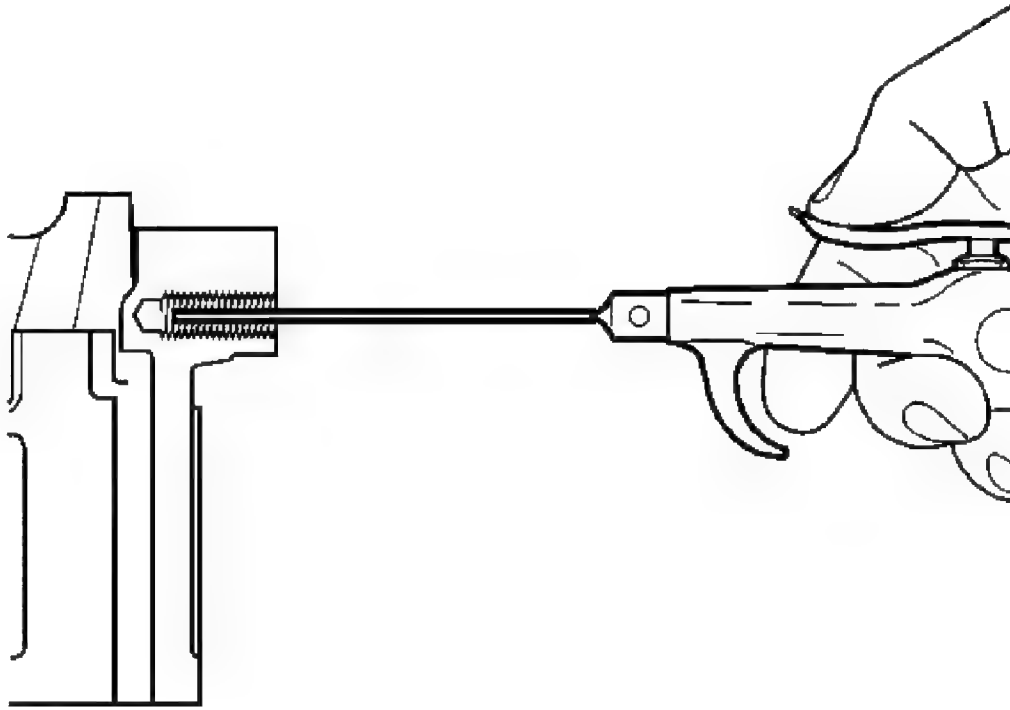


Fig. 208: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

7. Using compressed air, clean out any chips.

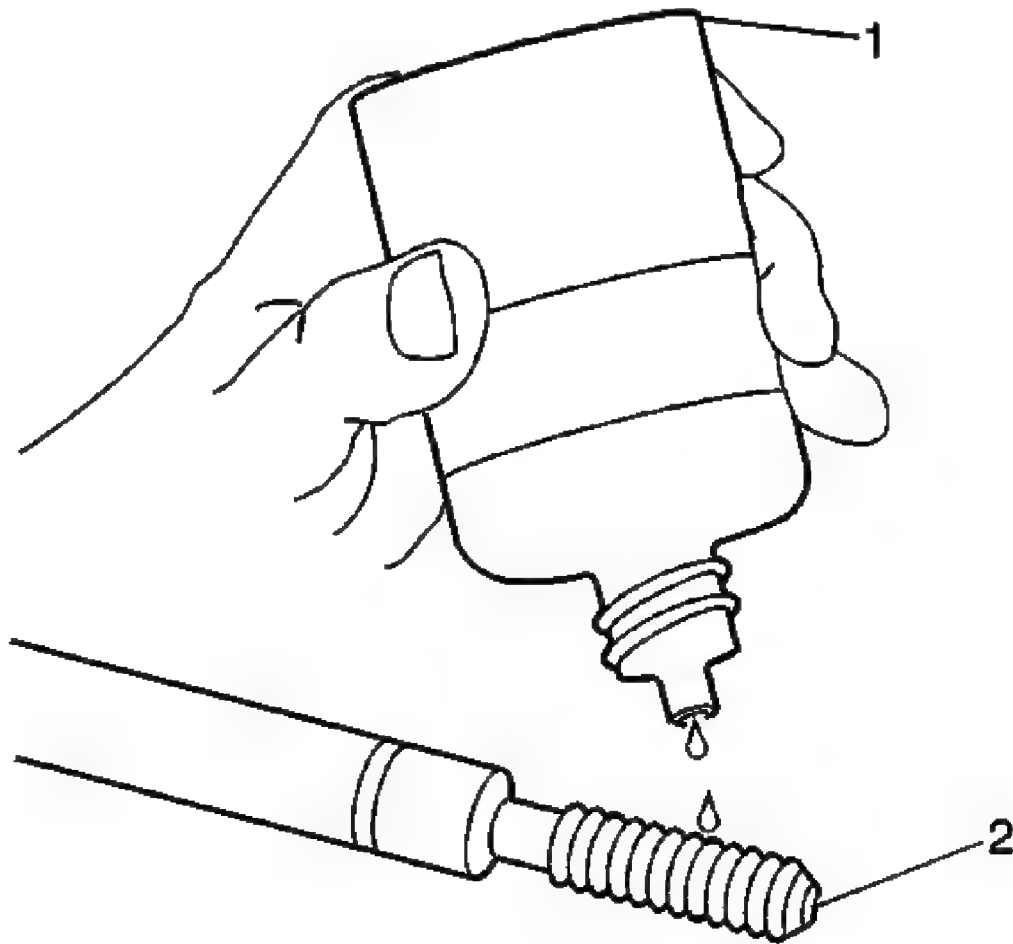


Fig. 209: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

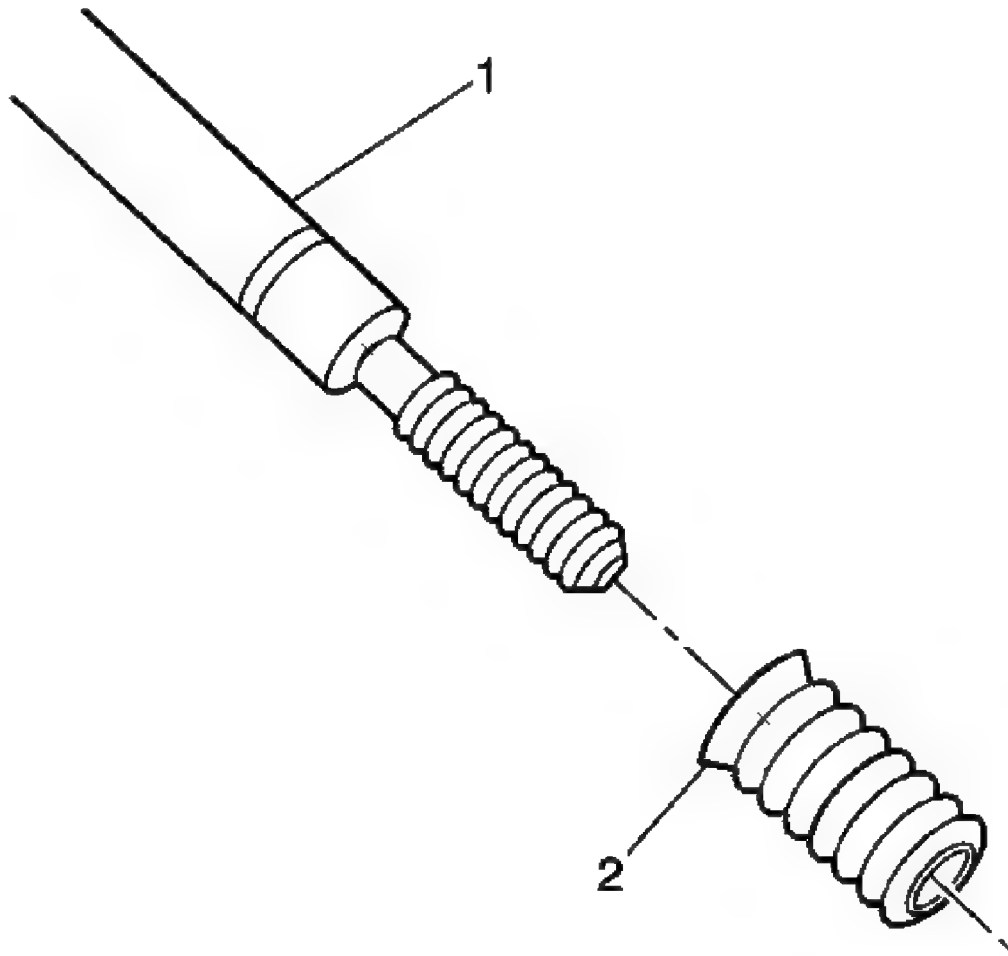


Fig. 210: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

9. Install the insert (2) onto the driver installation tool (1).

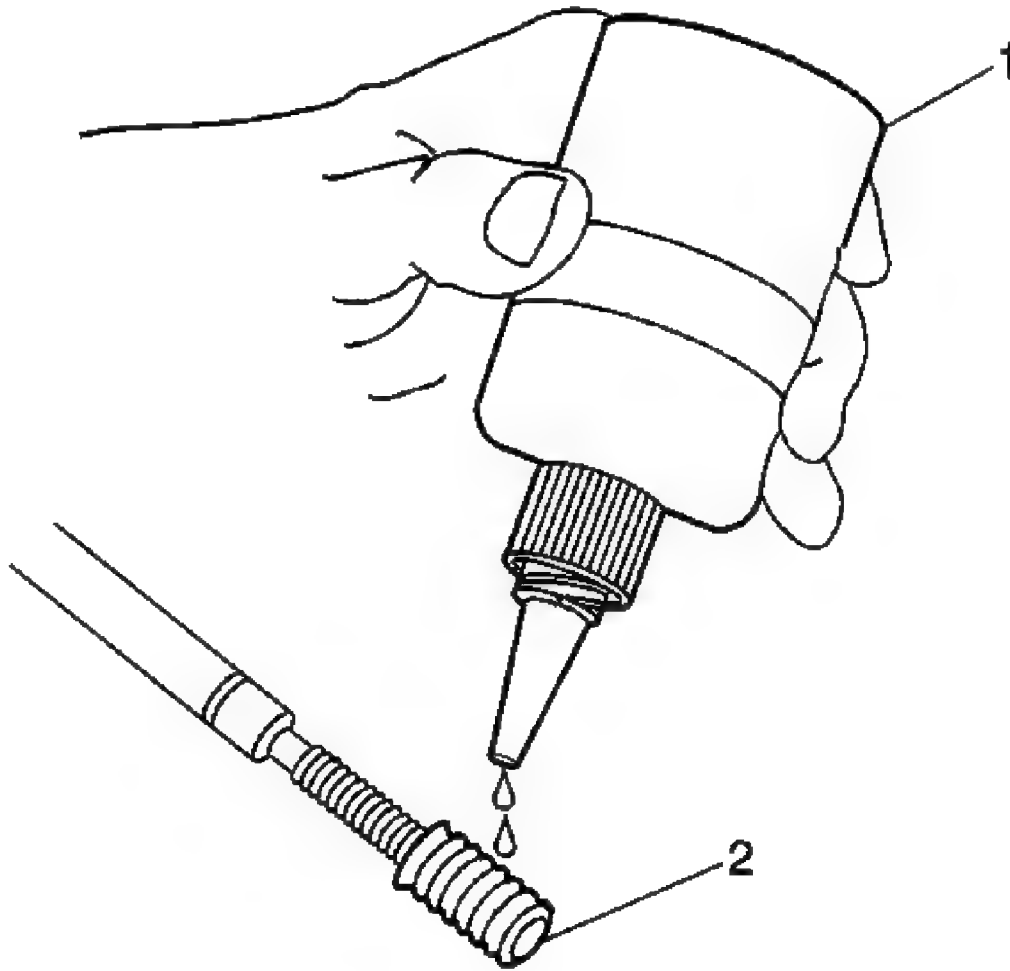


Fig. 211: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

10. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

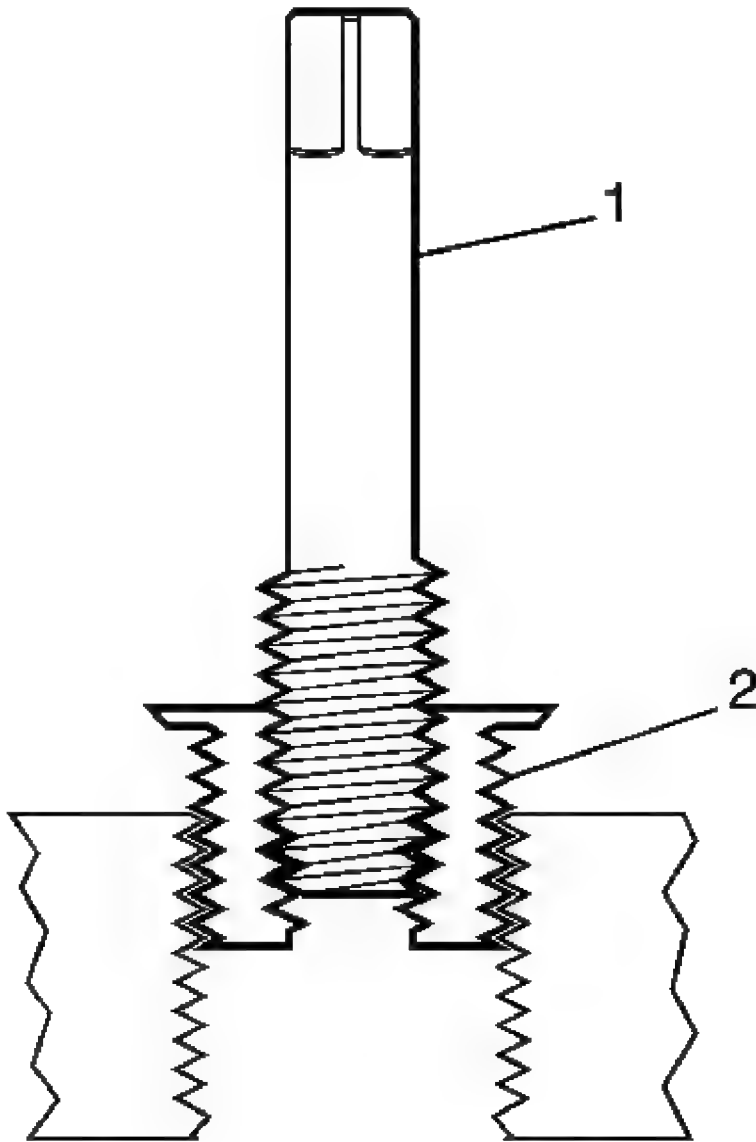


Fig. 212: Installing Insert - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) into the tapped hole by hand only.

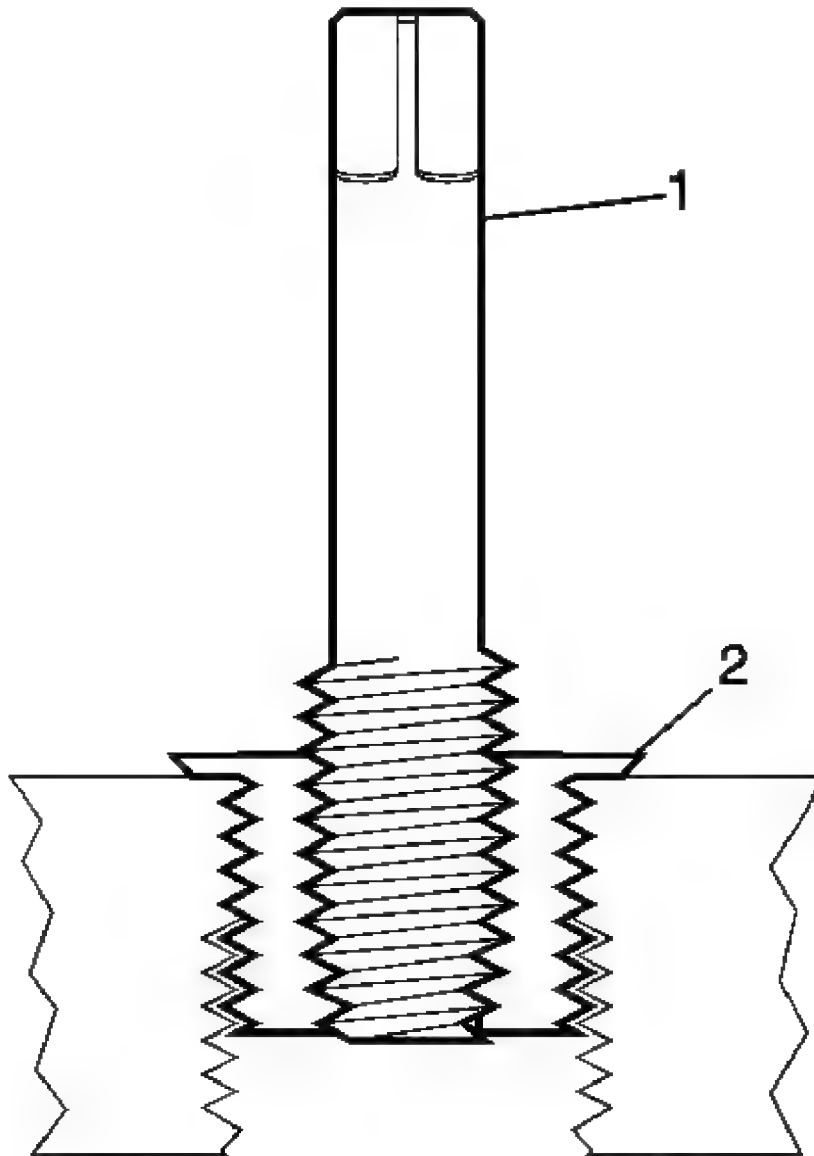


Fig. 213: Installing Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

12. Install the insert until the flange (2) of the insert contacts the surface of the base material.

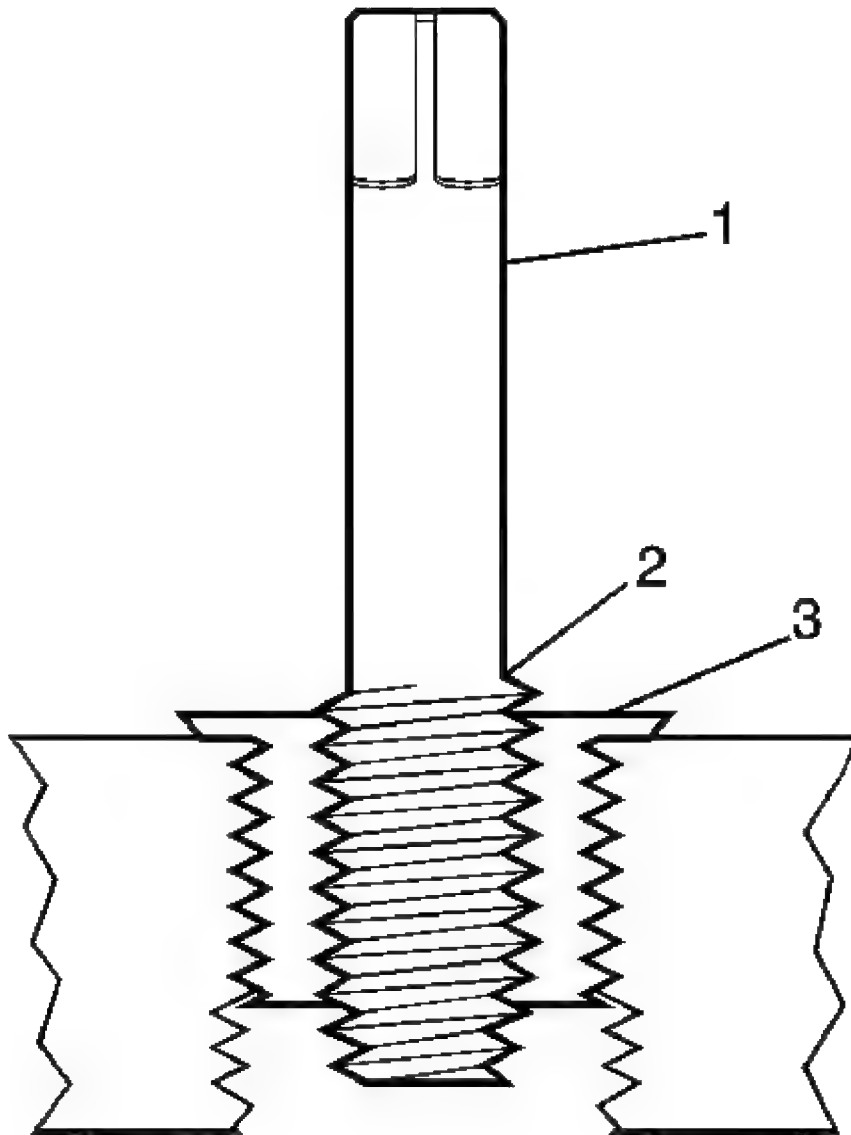


Fig. 214: Installed Insert - Tapered Pipe Thread Repair
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base

material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).

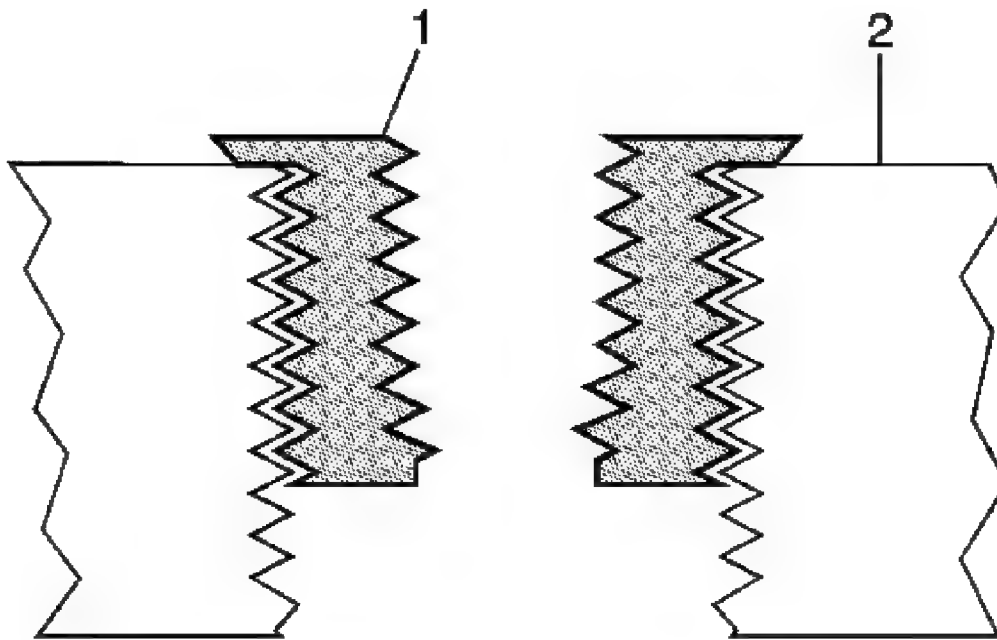


Fig. 215: Inspecting Insert For Proper Installation - Tapered Thread
Courtesy of GENERAL MOTORS CORP.

14. Inspect the insert (1) for proper installation (2) into the tapped hole.

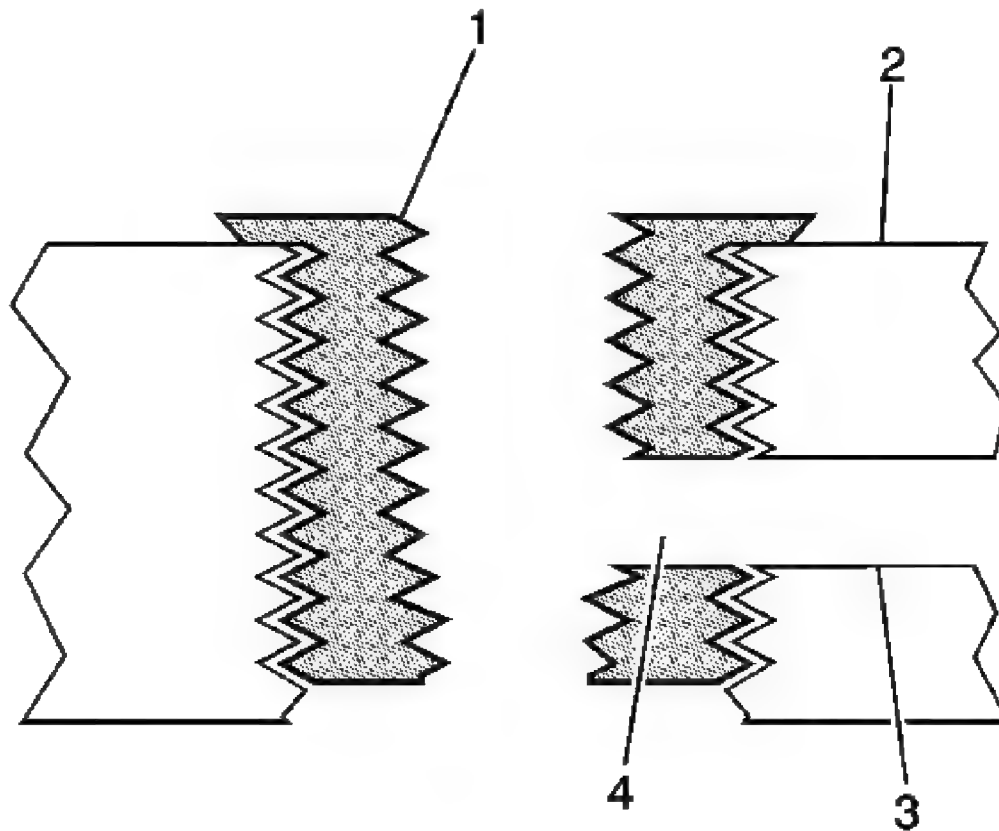


Fig. 216: View Of Restricted Engine Coolant Passages - Tapered Pipe Thread Repair

Courtesy of GENERAL MOTORS CORP.

15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

CYLINDER HEAD BOLT HOLE THREAD REPAIR

Tools Required

J 42385-2030 M11 x 2. See **Special Tools** .0 Cylinder Head Bolt - Northstar/Premium V8 Thread Insert Kit

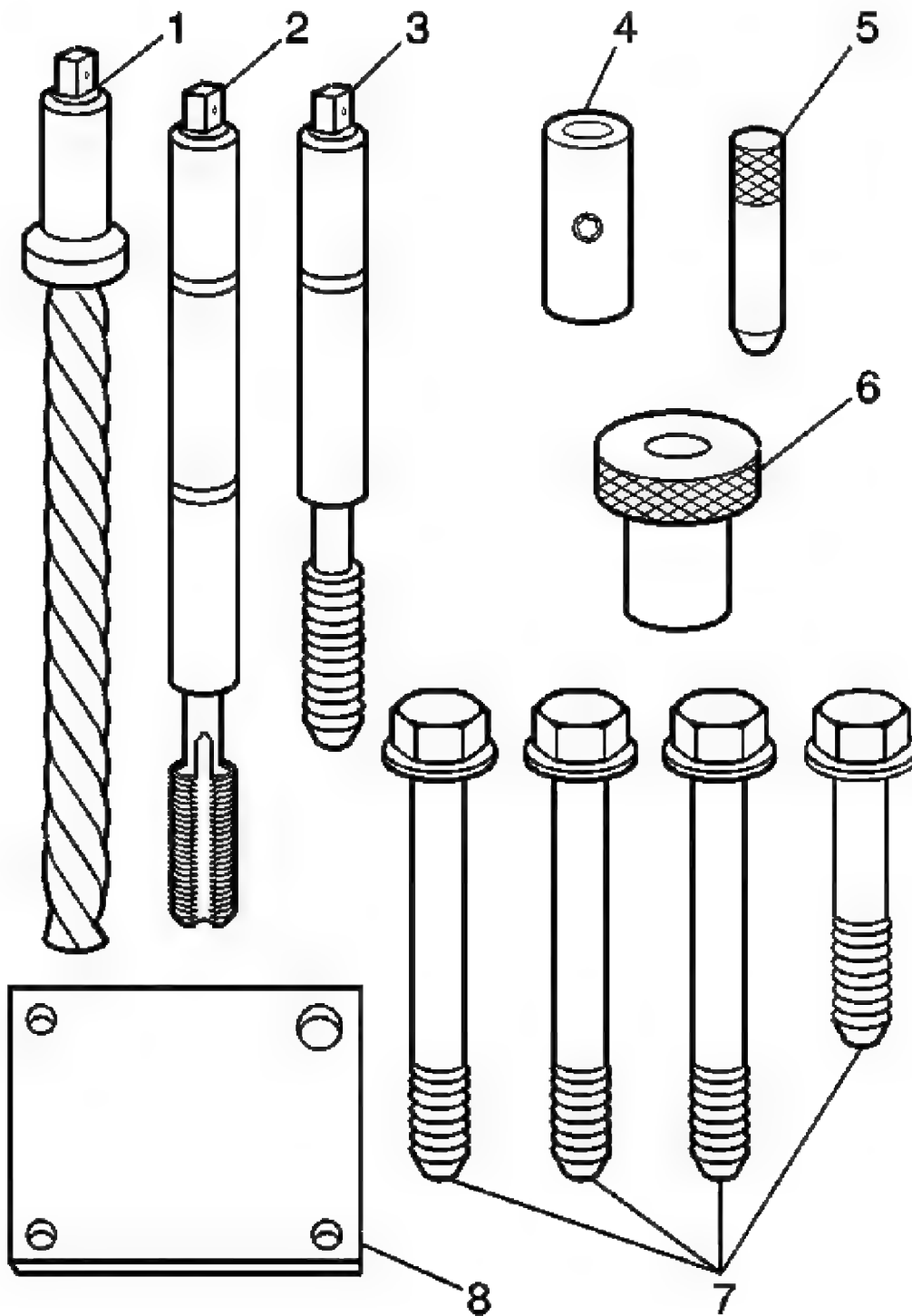


Fig. 217: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

The cylinder head bolt hole thread repair kit **J 42385-2030** components consist of the following: See **Special Tools** .

- Drill (1) J 42385-2031
- Tap (2) J 42385-2032
- Installation driver (3) J 42385-2033
- Stop collar (4) for inboard holes J 42385-2034
- Alignment pin (5) J 42385-303
- Bushing (6) J 42385-302
- Bolts (7) J 42385-2035 and J 42385-2036
- Fixture plate (8) J 42385-301

NOTE: **Ensure the cylinder head bolts, tools and inserts that are being used are the proper pitch or engine damage will occur. The thread pitch on the M11 cylinder head bolts and the engine block cylinder head bolt holes have been revised. In order to install the proper pitch insert it is important to identify which thread pitch is being used. Cylinder head bolts with a pitch of 1.5 mm have a thread length of about 48 mm (1.890 in) long. Cylinder head bolts with a pitch of 2.0 mm have a thread length of about 67 mm (2.638 in) long.**

IMPORTANT:

- **Cylinder head bolt holes with a pitch of 2.0 mm (0.08 in) use the tooling from the J 42385-2030 . See Special Tools . Cylinder head bolt holes with a pitch of 1.5 mm (5.90 in) use the tooling from the J 42385-2000 . See Special Tools .**
- **Verify the depth of the cylinder head bolt hole and the pitch of the cylinder head bolt threads. Measure the depth from the deck surface of the block to the bottom of the cylinder head hole. All cylinder head holes should use only one of the bushings. Never use both bushings to repair a block.**

With M11 bolts with a 1.5 mm pitch:

- Use the bushing J 42385-2022 for inboard holes that measure 73 mm (2.874 in) deep and outboard holes that measure 89.5 mm (3.524 in) deep.
- Use the bushing J 42385-302 for inboard holes that measure 80 mm (3.150 in) deep and outboard holes that measure 96.5 mm (3.799 in) deep.

With M11 bolts with 2.0 mm pitch:

Use the bushing J 42385-302 for inboard holes that measure 73 mm (2.874 in) deep and outboard holes that measure 89.5 mm (3.524 in) deep.

INBOARD BOLT HOLES

CAUTION: Refer to Safety Glasses Caution .

- IMPORTANT:**
- Remove the fixture plate prior to installing the insert with the installer tool.
 - The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

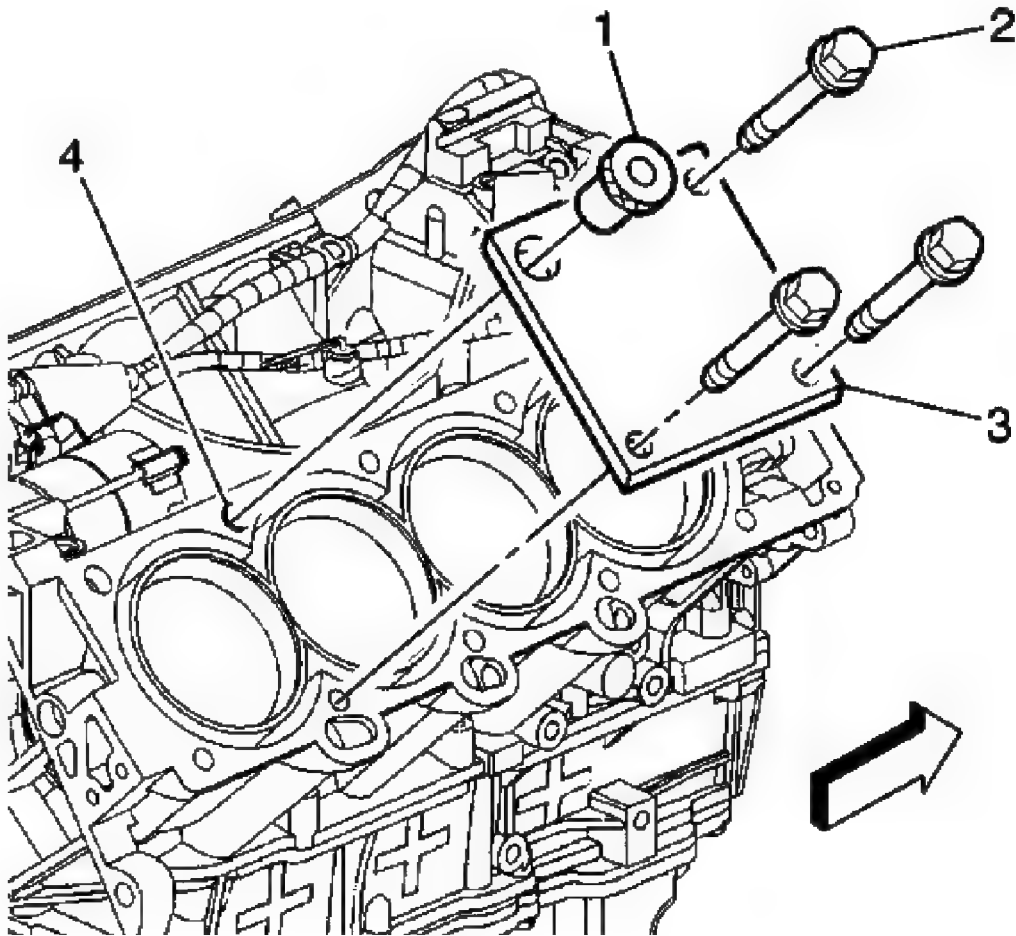


Fig. 218: View Of Fixture Plate, Bushing & Bolts - Inboard
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.

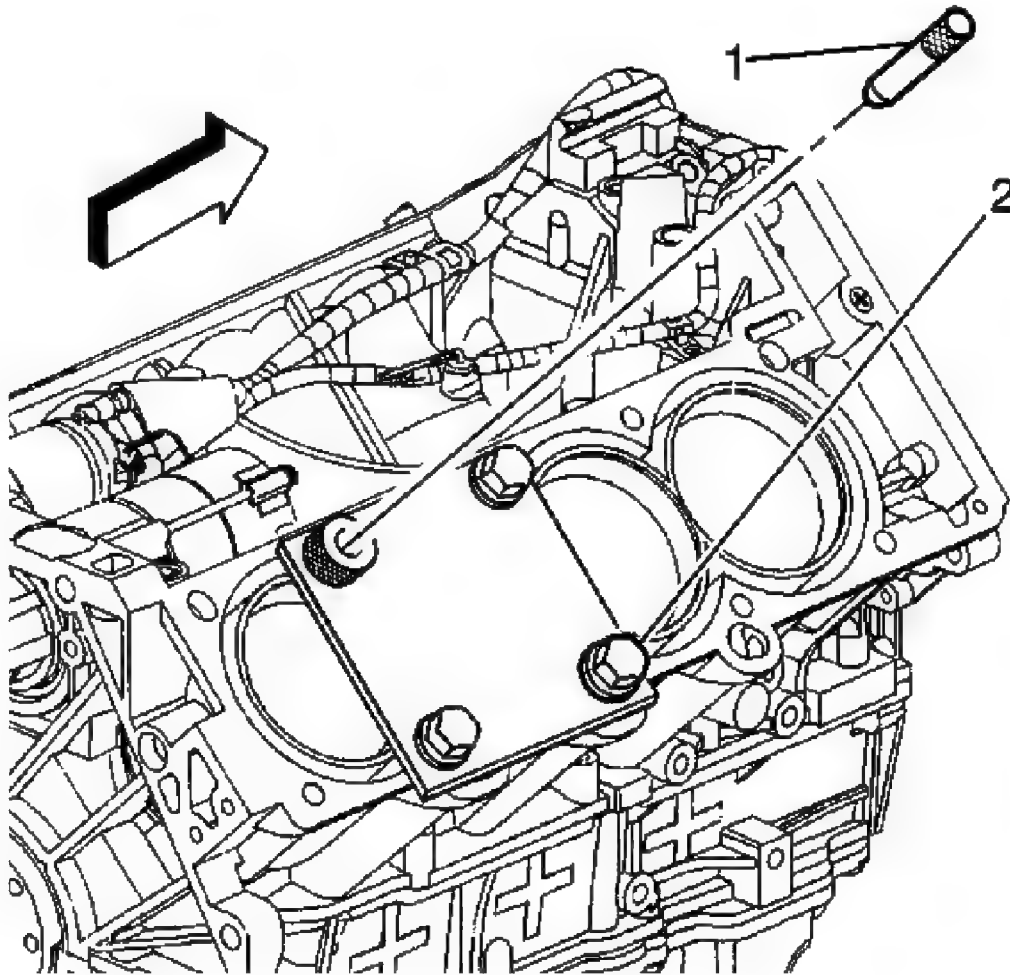


Fig. 219: Identifying Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.
4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

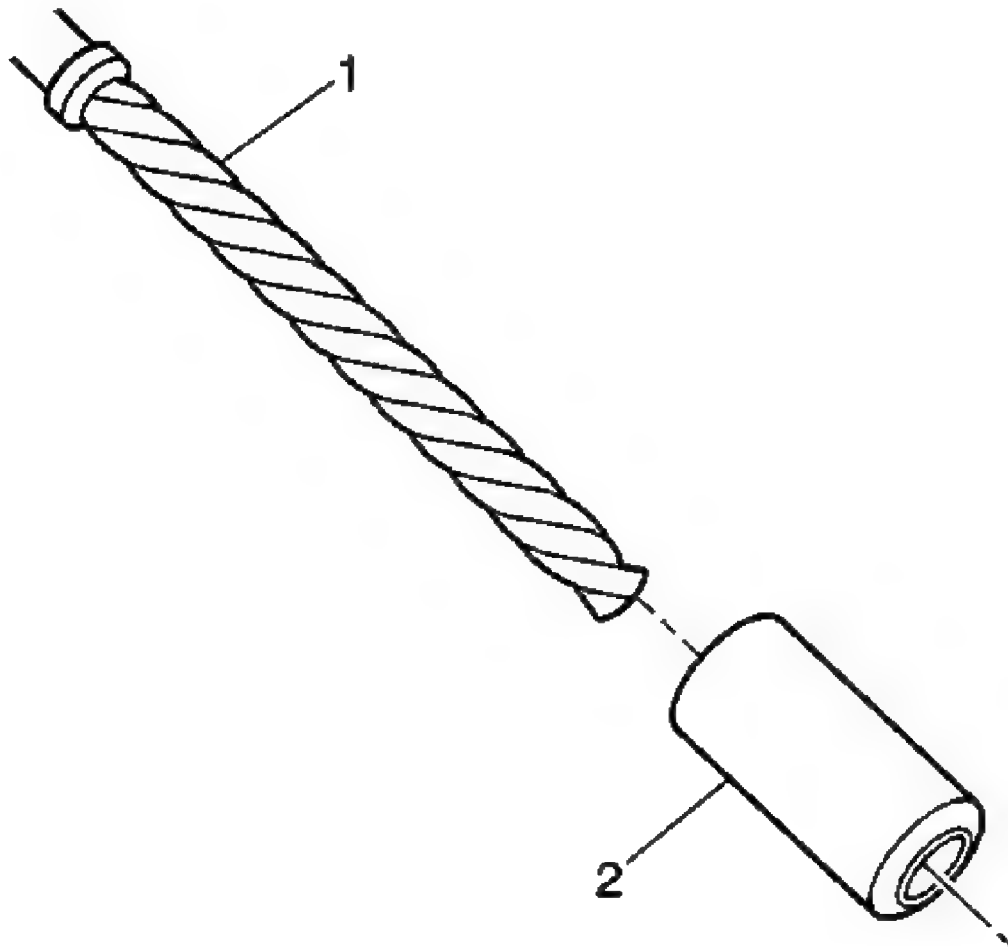


Fig. 220: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the stop collar (2) onto the drill (1).

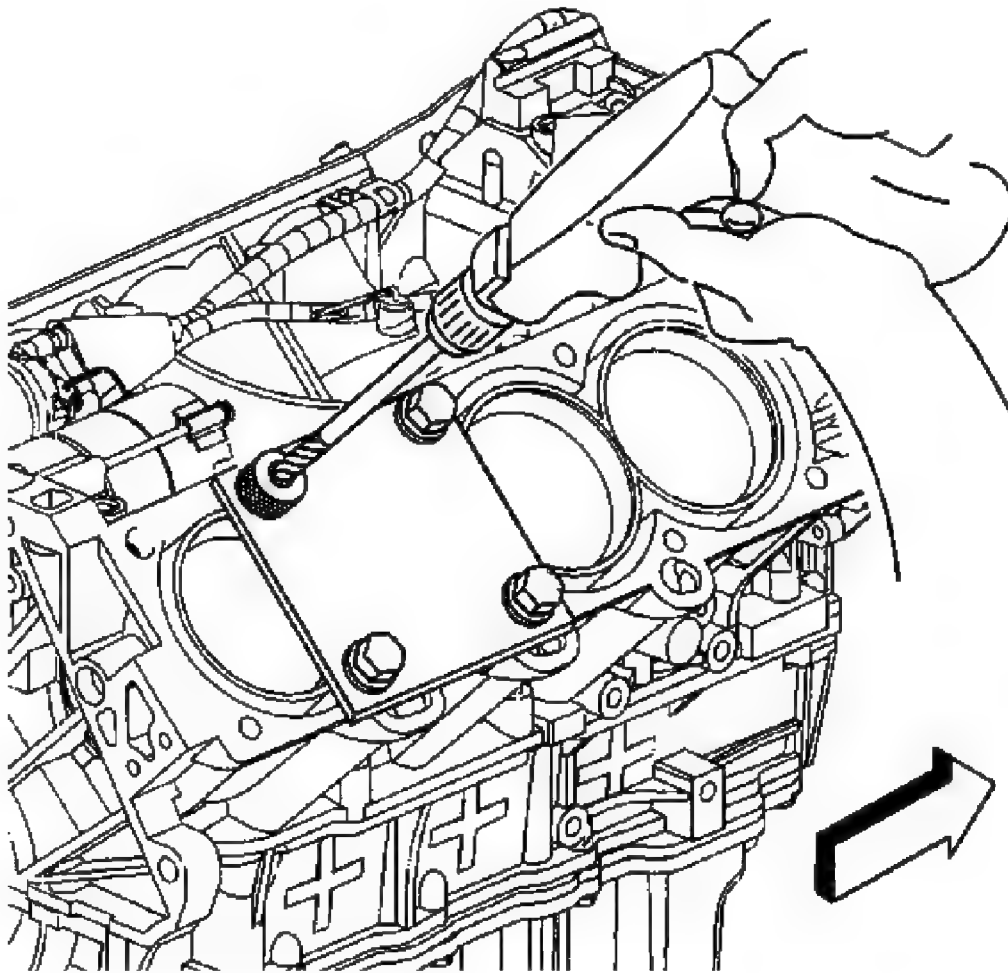


Fig. 221: View Of Drilling Process - Inboard
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the top of the drill bushing.

7. Drill out the threads of the damaged hole.

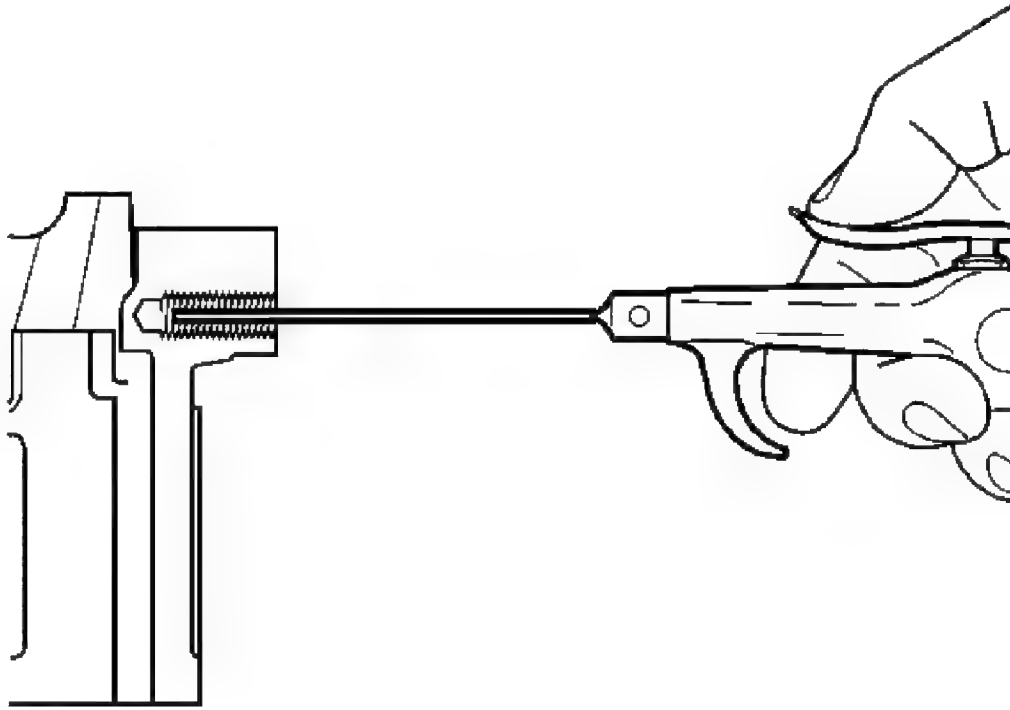


Fig. 222: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

8. Using compressed air, clean out any chips.

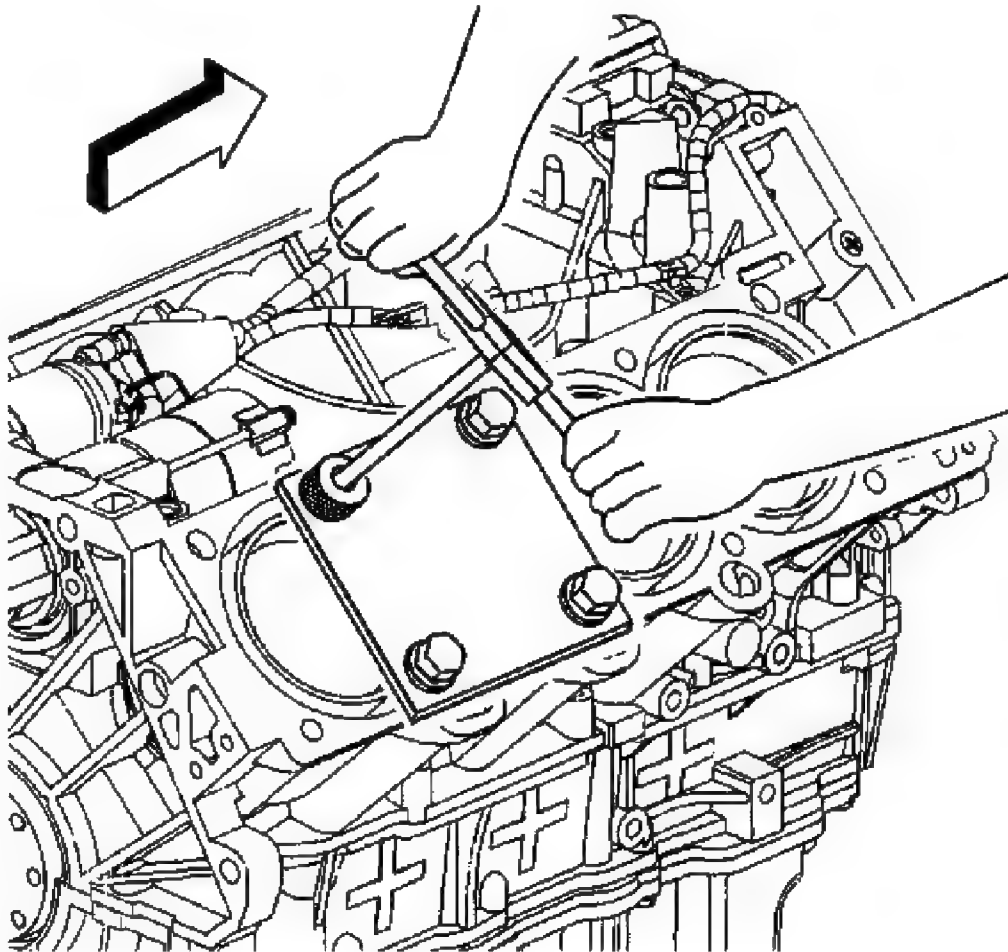


Fig. 223: Tapping Threads Using Tapping Wrench - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

9. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

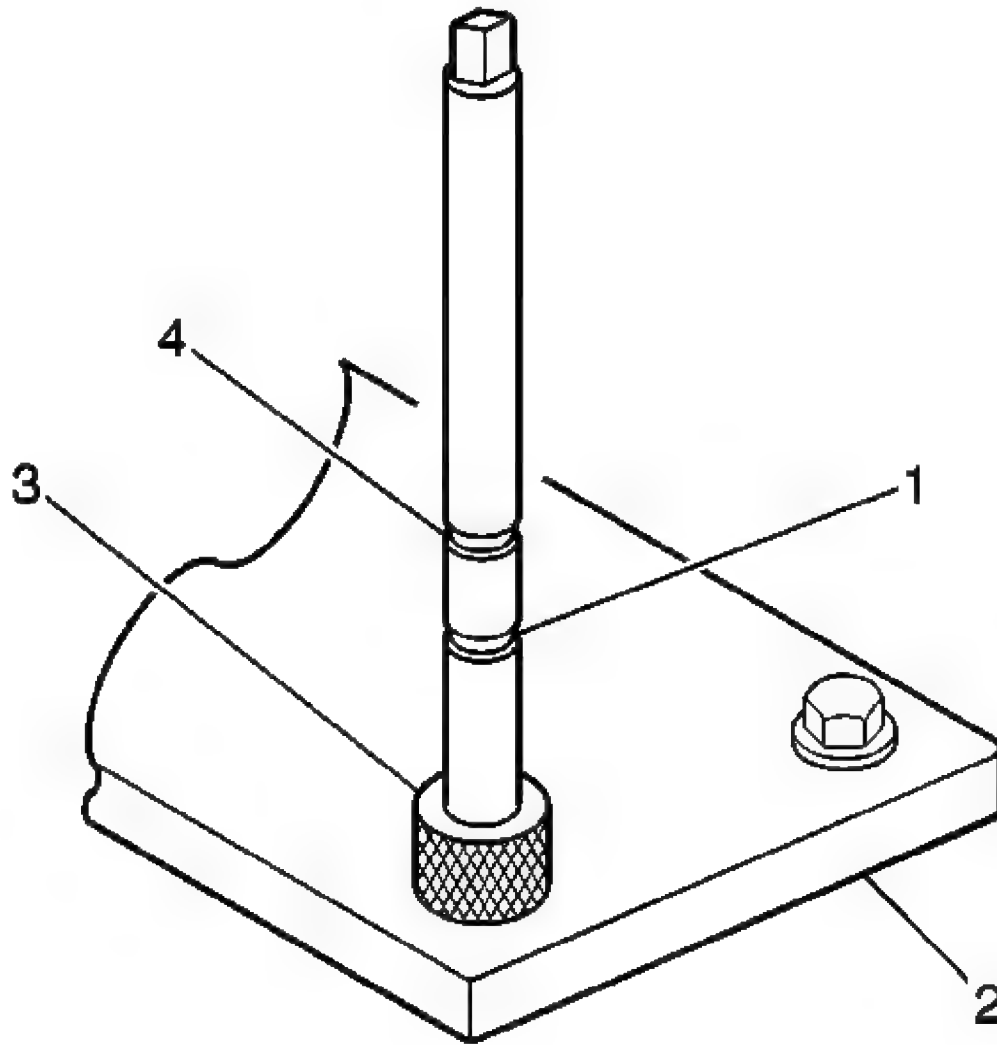


Fig. 224: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

10. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the first mark (1) on the tap aligns with the top of the drill bushing (3).

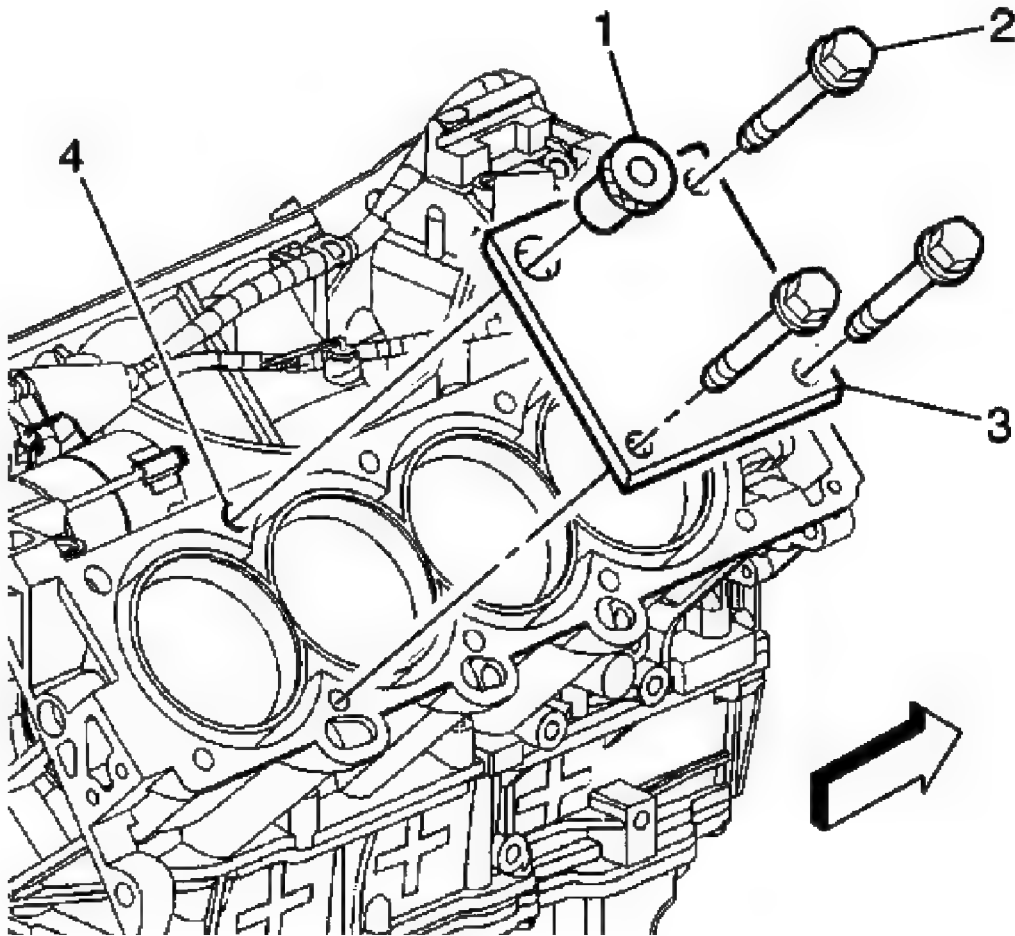


Fig. 225: View Of Fixture Plate & Components - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the fixture plate prior to installing the insert with the installer tool.

11. Remove the fixture plate bolts (2).
12. Remove the fixture plate (3) and bushing (1).

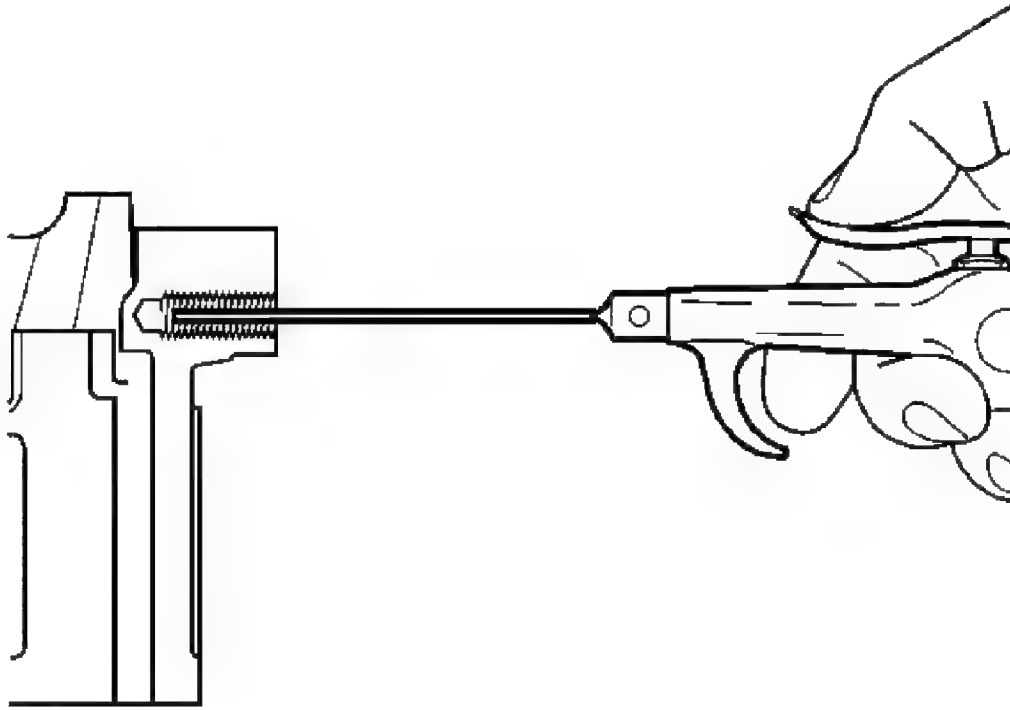


Fig. 226: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

13. Using compressed air, clean out any chips.

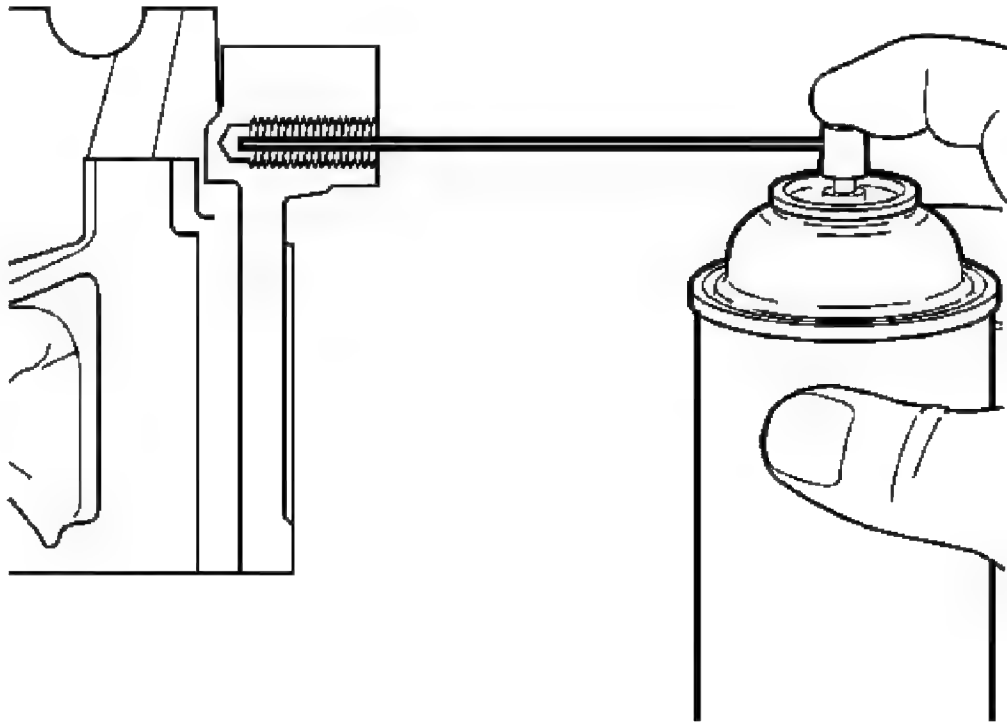


Fig. 227: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

14. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

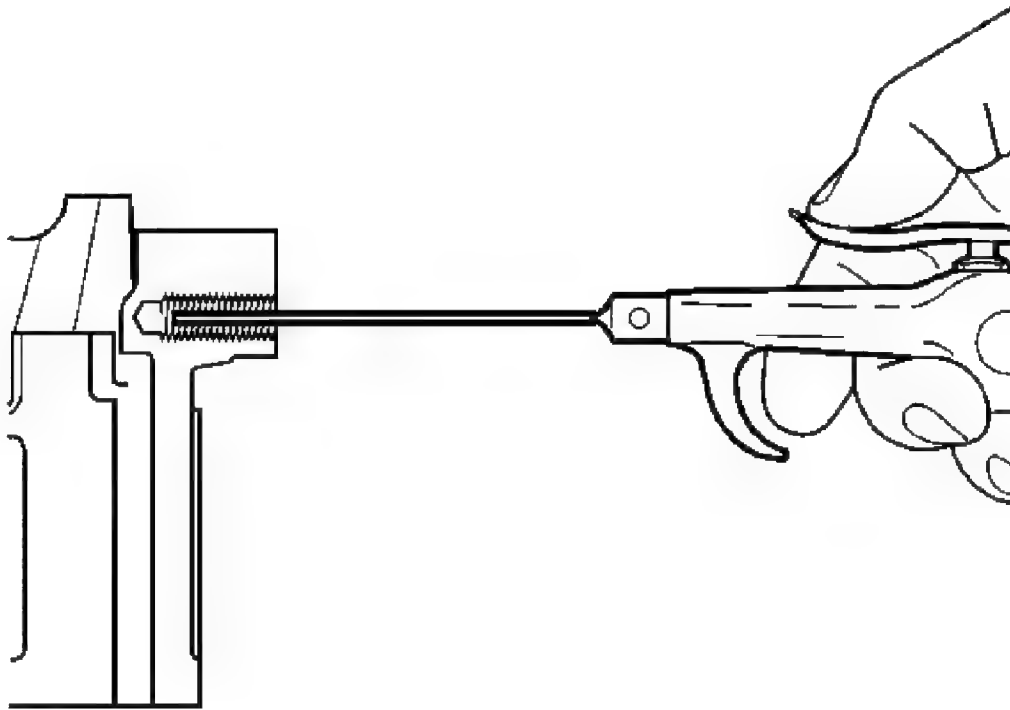


Fig. 228: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

15. Using compressed air, clean out any chips.

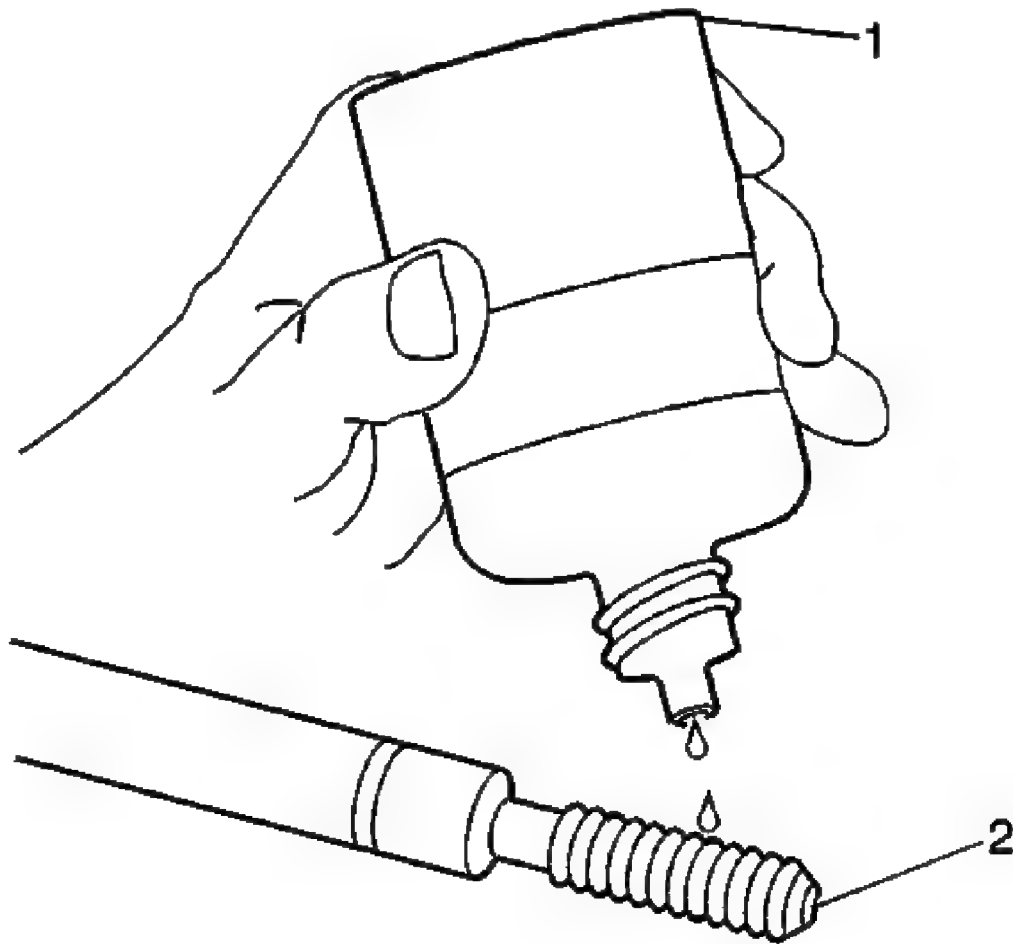


Fig. 229: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

16. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

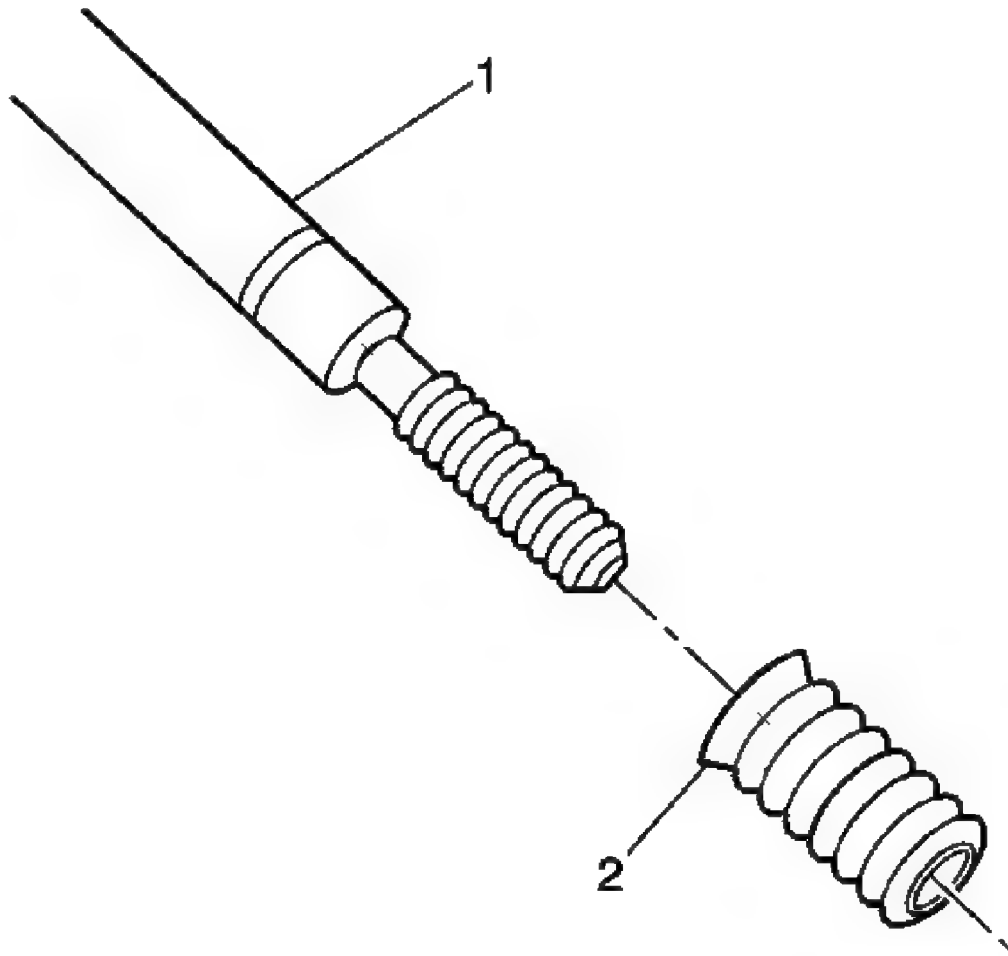


Fig. 230: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

17. Install the insert (2) onto the driver installation tool (1).

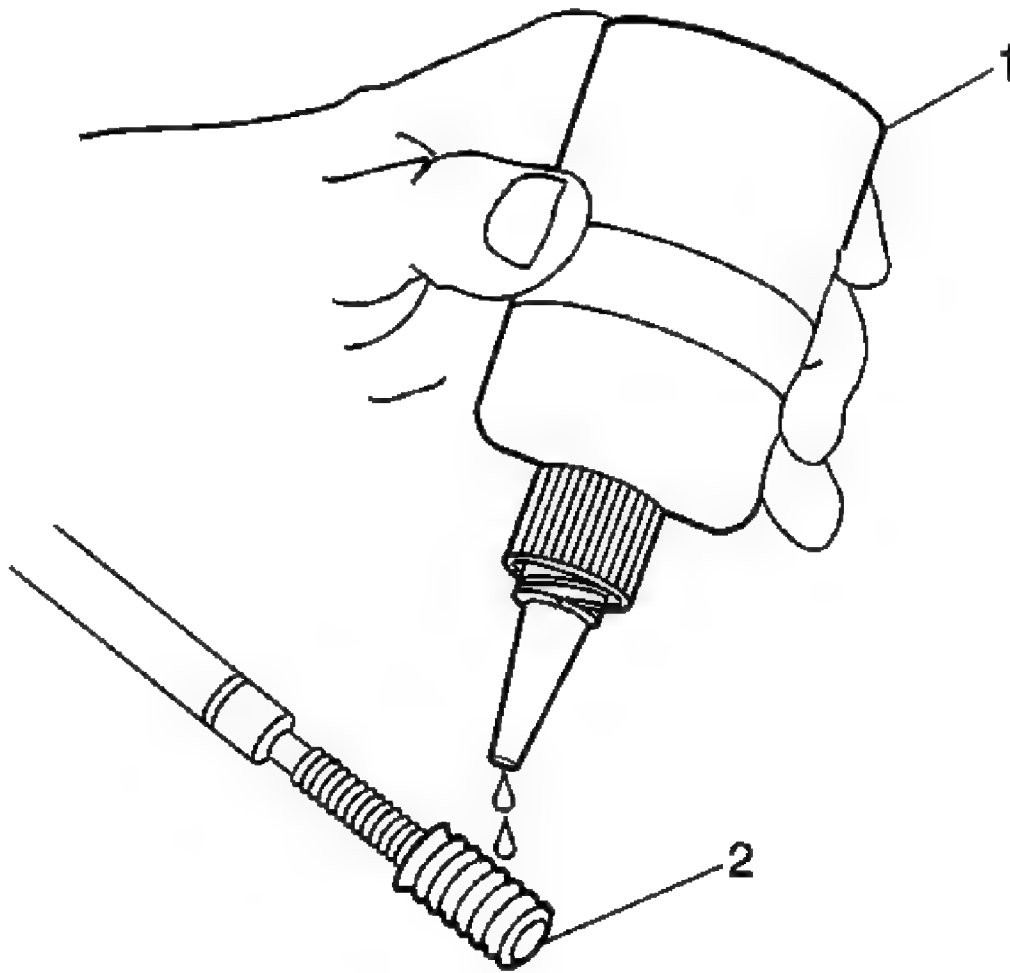


Fig. 231: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

18. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

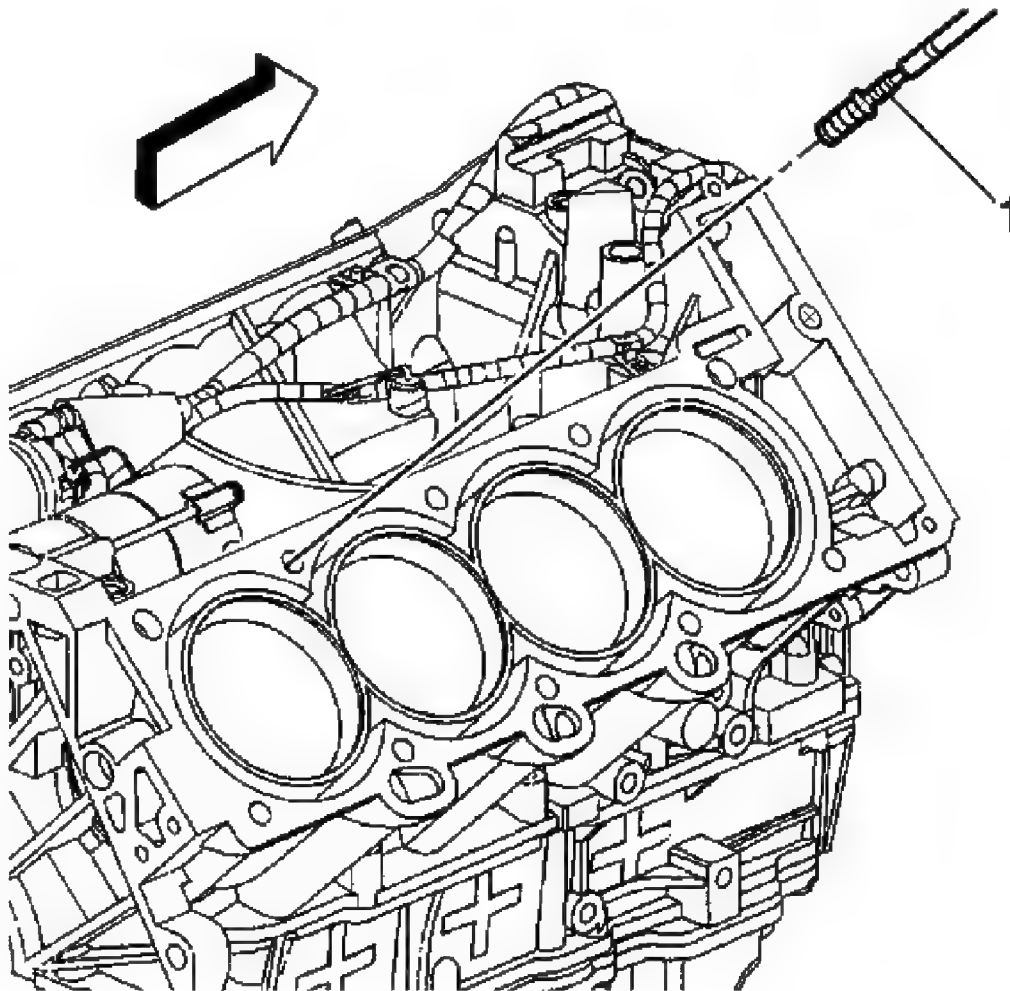


Fig. 232: Installing Insert & Installation Driver - Inboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

19. Install the insert and installation driver (1) into the tapped hole by hand only.
20. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

21. Install the insert until the flange of the insert contacts the counterbored surface.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

22. Continue to rotate the driver installation tool through the insert.
23. Inspect the insert for proper installation into the tapped hole.

OUTBOARD BOLT HOLES

CAUTION: Refer to Safety Glasses Caution .

- IMPORTANT:**
- Remove the fixture plate prior to installing the insert with the installer tool.
 - The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

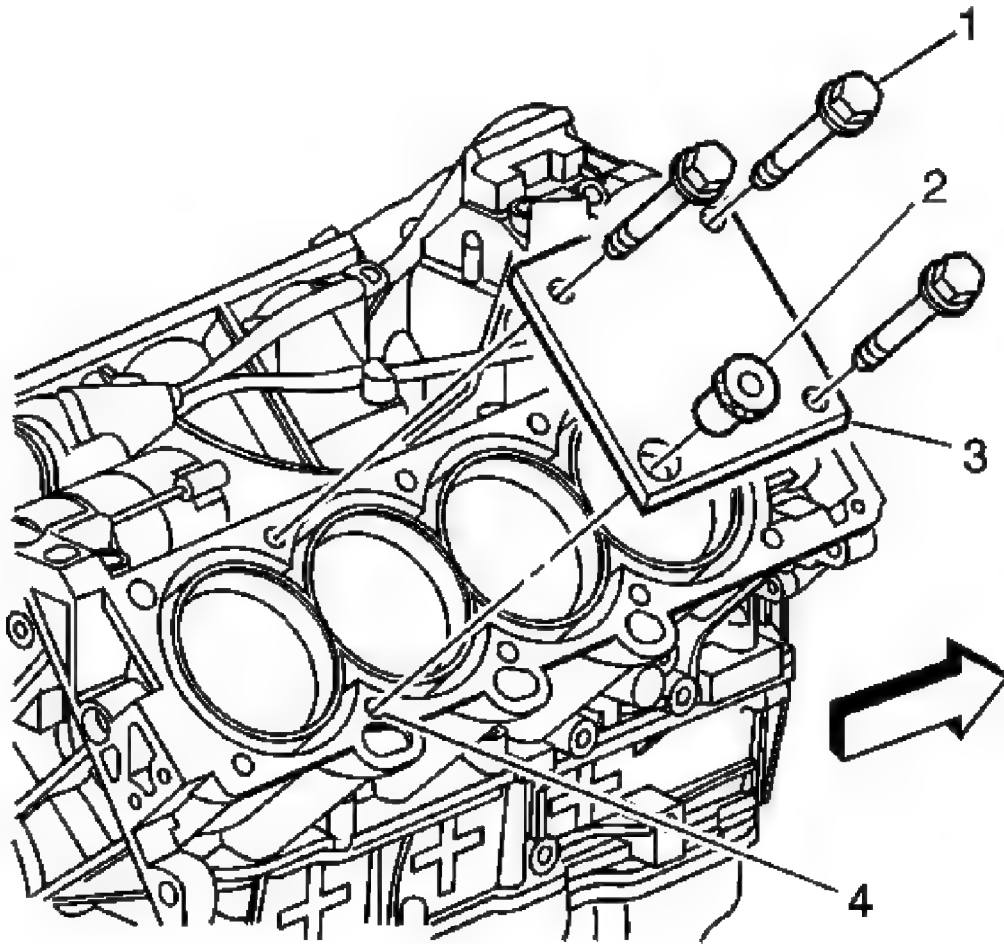


Fig. 233: View Of Fixture Plate & Components - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (2) installed over the cylinder head bolt hole to be repaired (4).
2. Loosely install the fixture plate bolts (1) into the remaining cylinder head bolt holes.

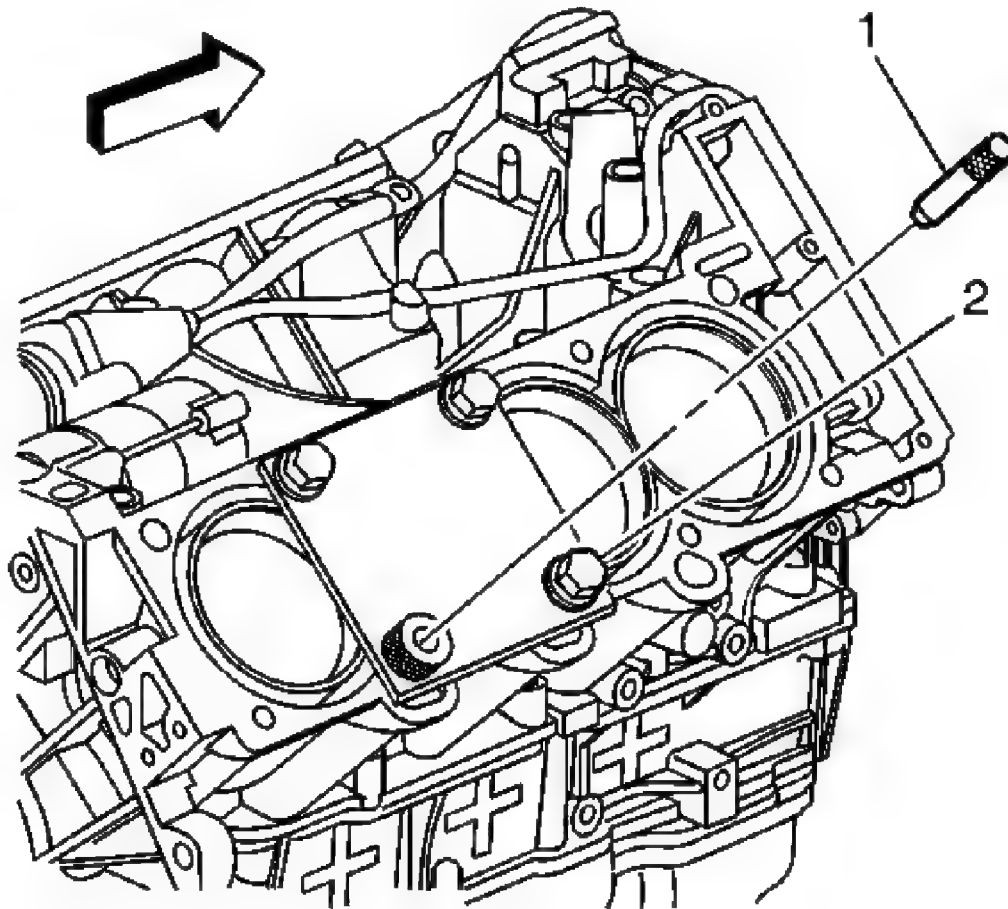


Fig. 234: Positioning Alignment Pin - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.
4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

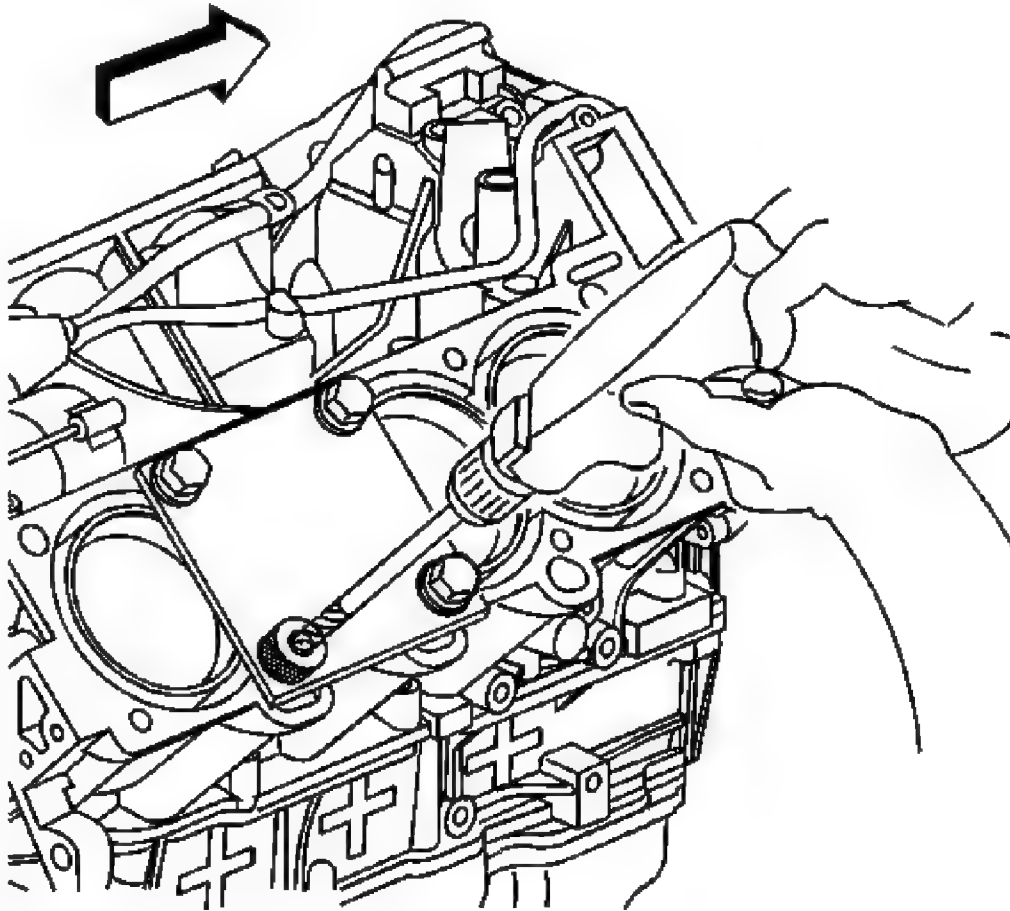


Fig. 235: Drilling Out Threads Of Damaged Hole - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the top of the drill bushing.

6. Drill out the threads of the damaged hole.

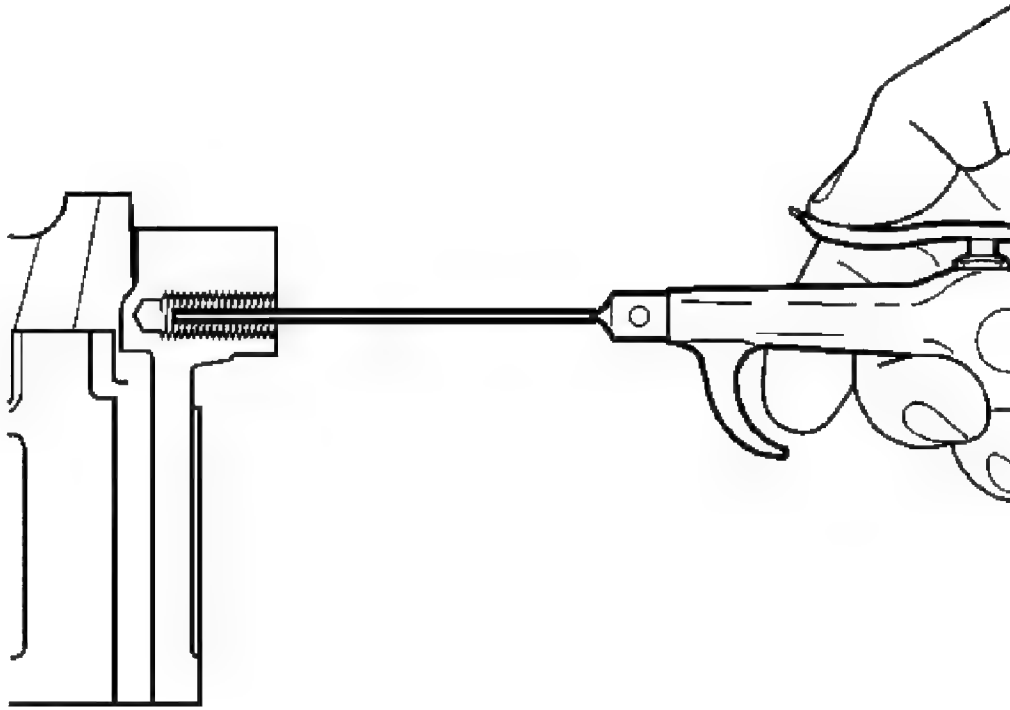


Fig. 236: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

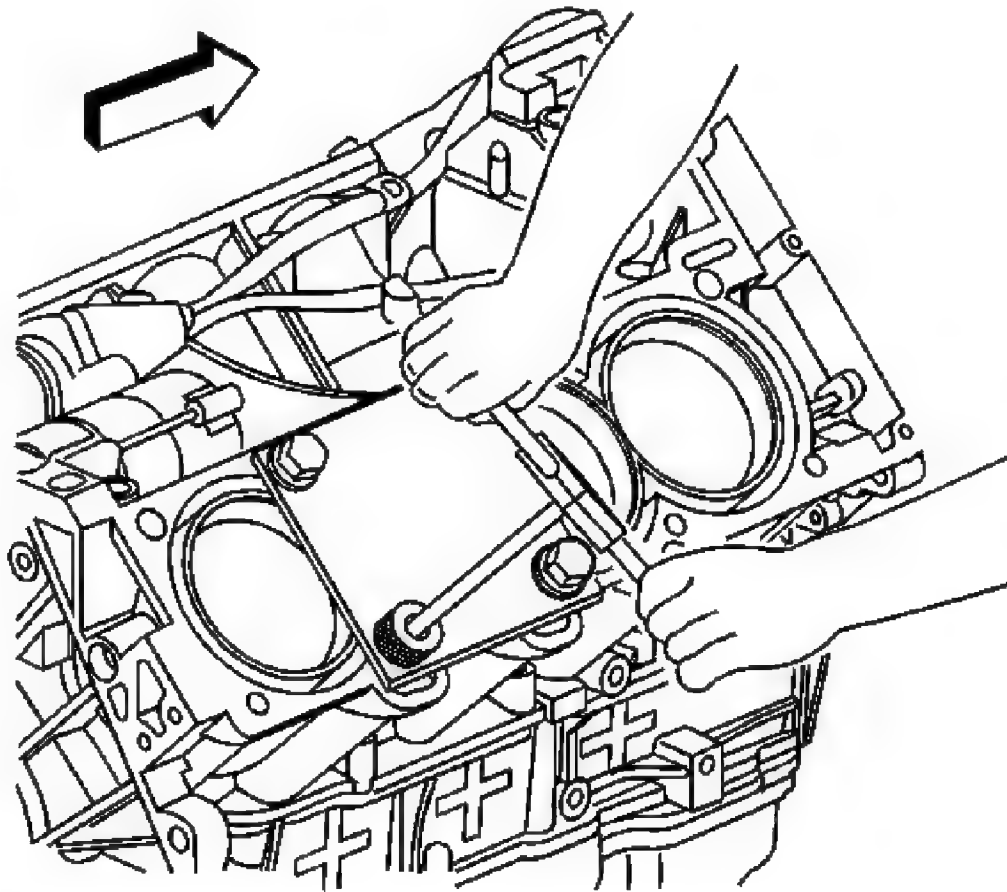


Fig. 237: Tapping Threads Using Tapping Wrench - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

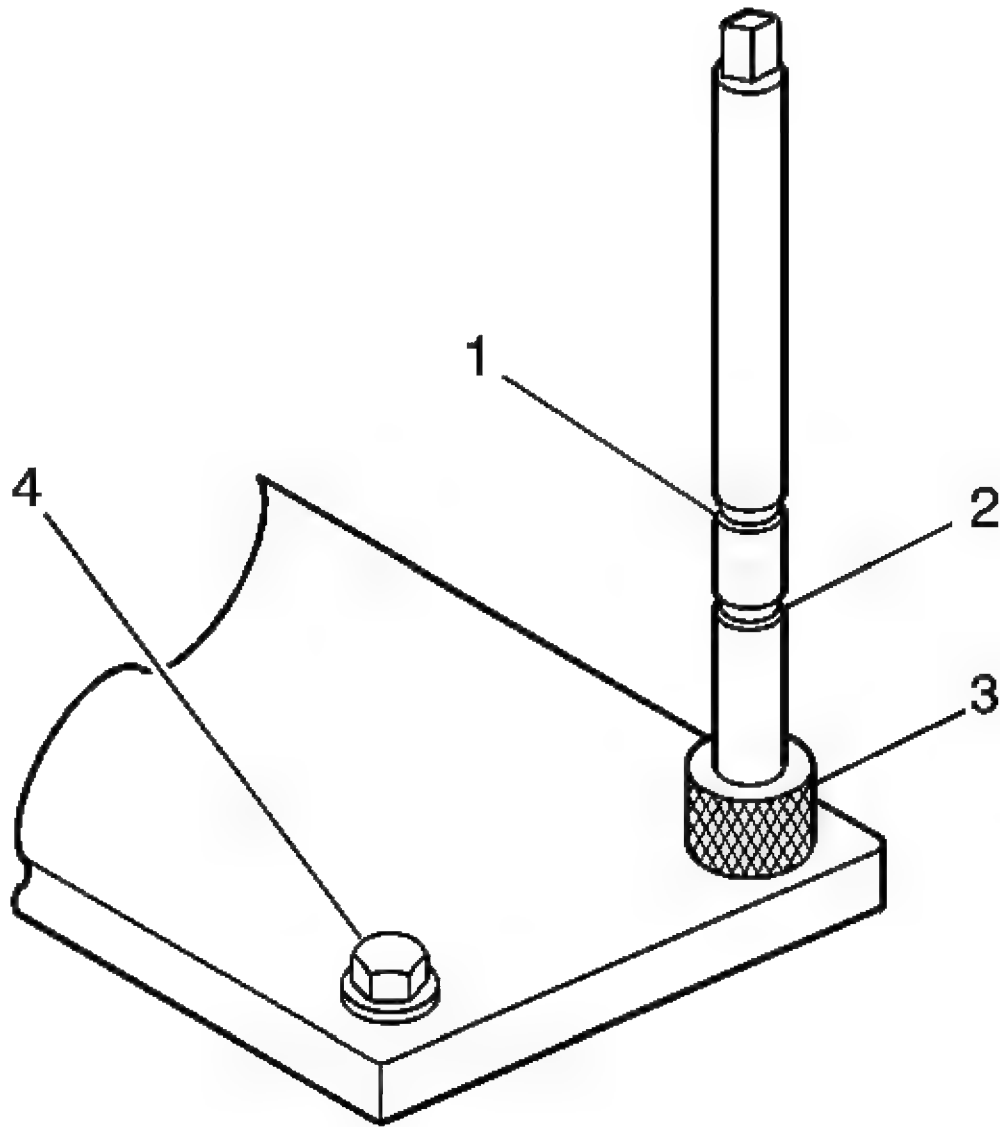


Fig. 238: Rotating Tap Into Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the second mark (1) on the tap aligns with the top of the drill bushing (3).

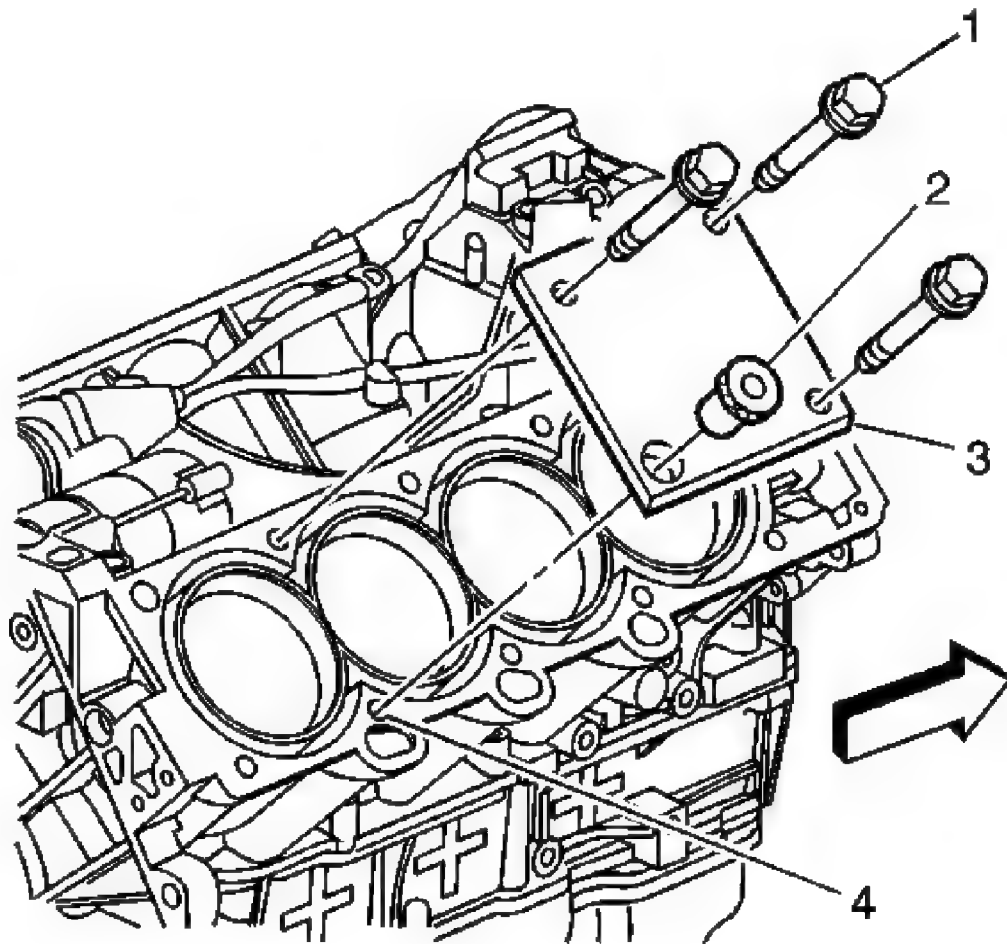


Fig. 239: View Of Fixture Plate & Components - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the fixture plate prior to installing the insert with the installer tool.

10. Remove the fixture plate bolts (1).
11. Remove the fixture plate (3) and bushing.

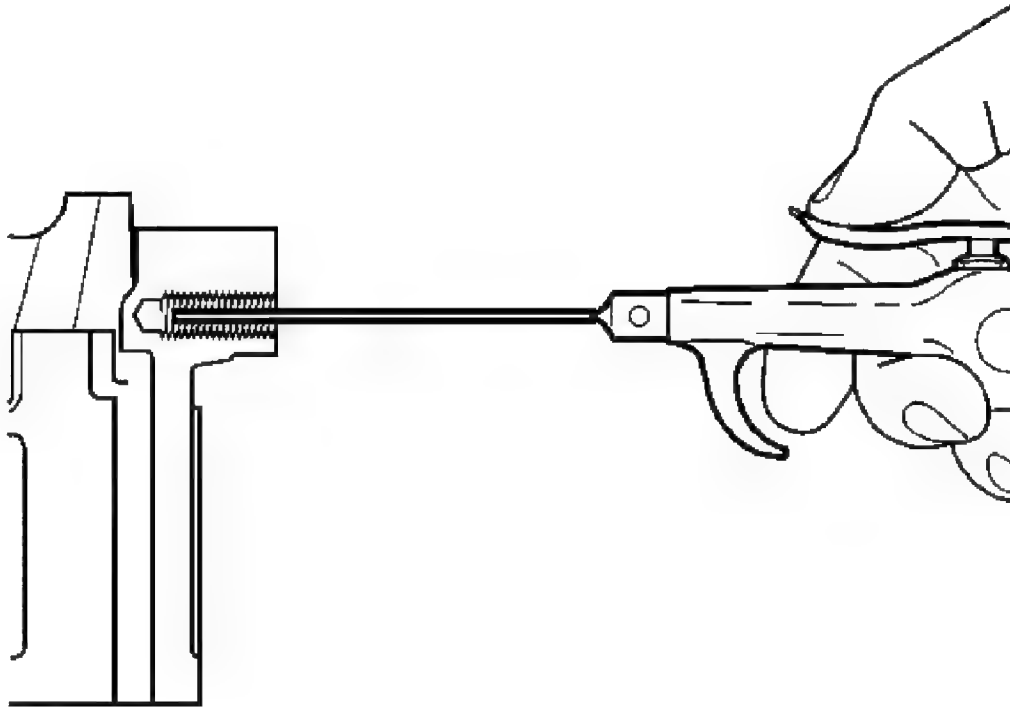


Fig. 240: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

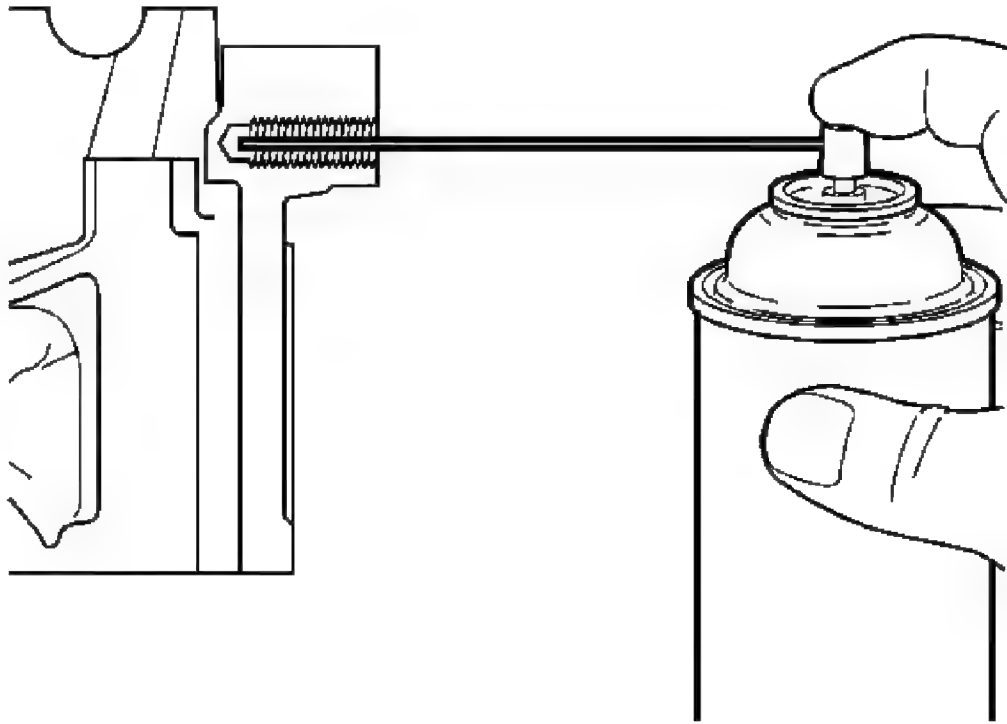


Fig. 241: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

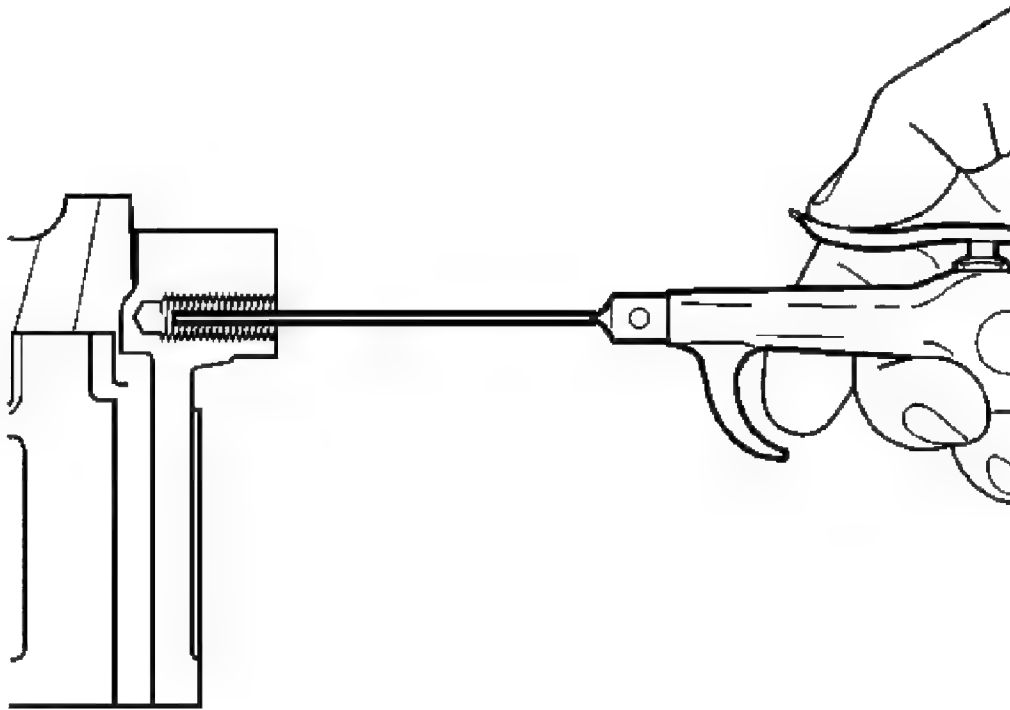


Fig. 242: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

14. Using compressed air, clean out any chips.

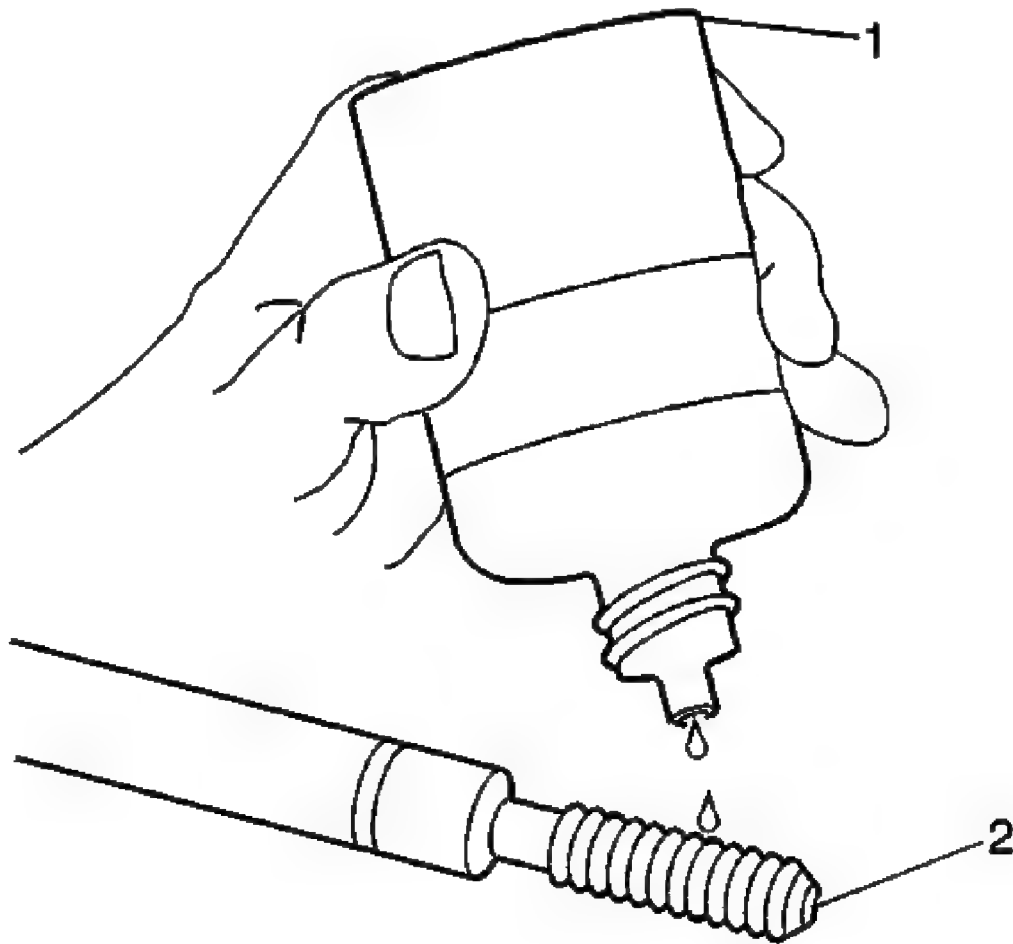


Fig. 243: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the OD of the insert.

15. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

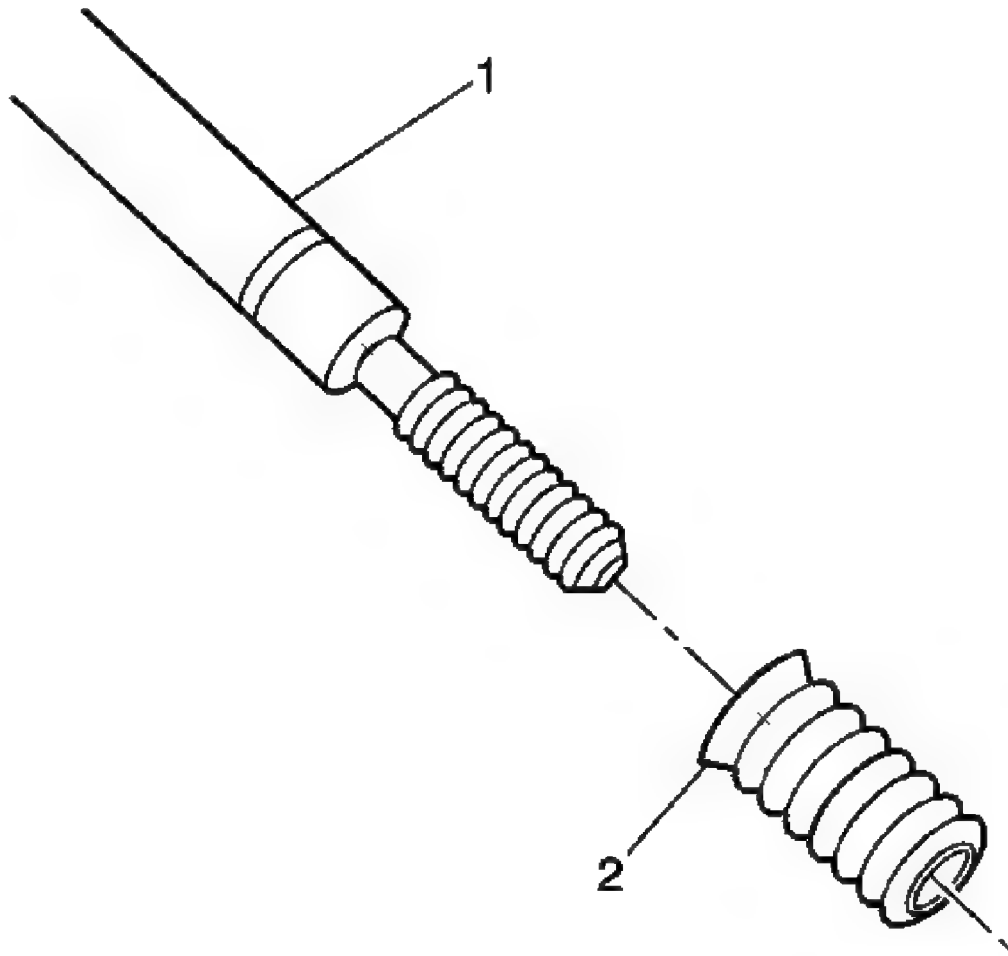


Fig. 244: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver installation tool (1).

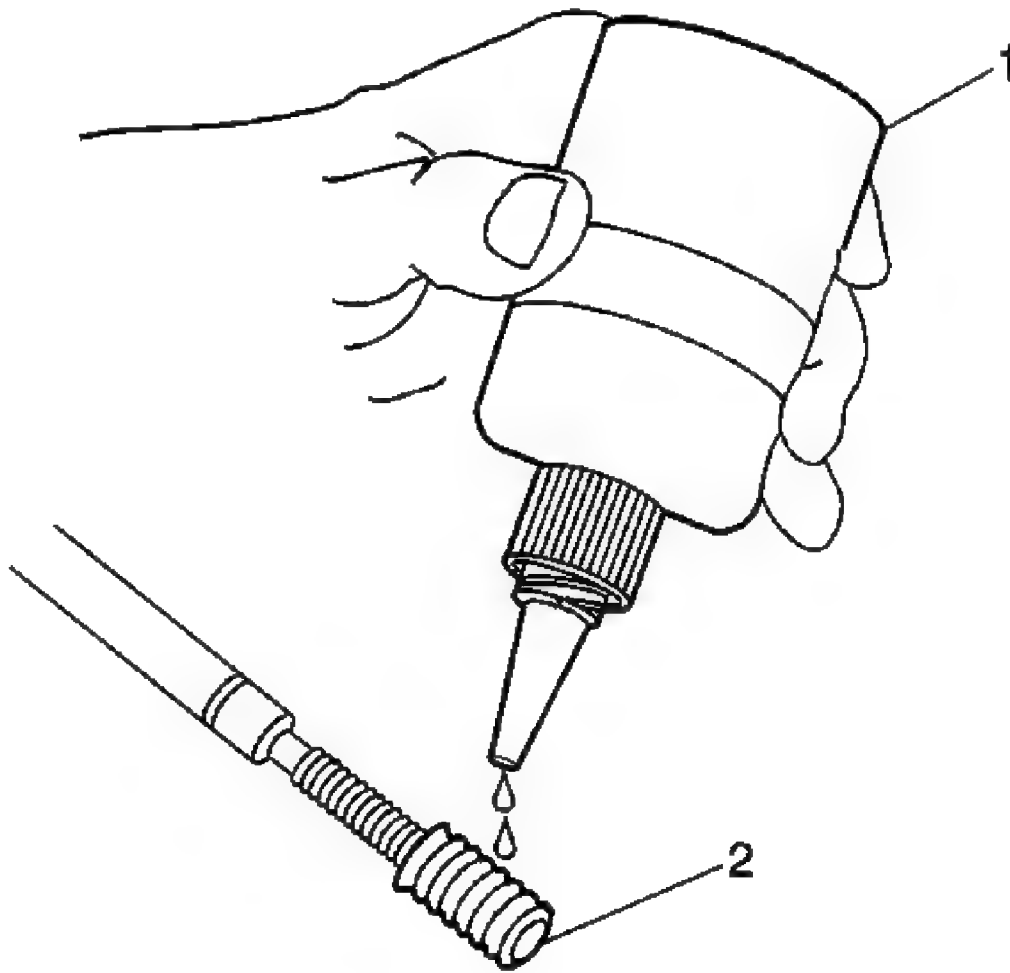


Fig. 245: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

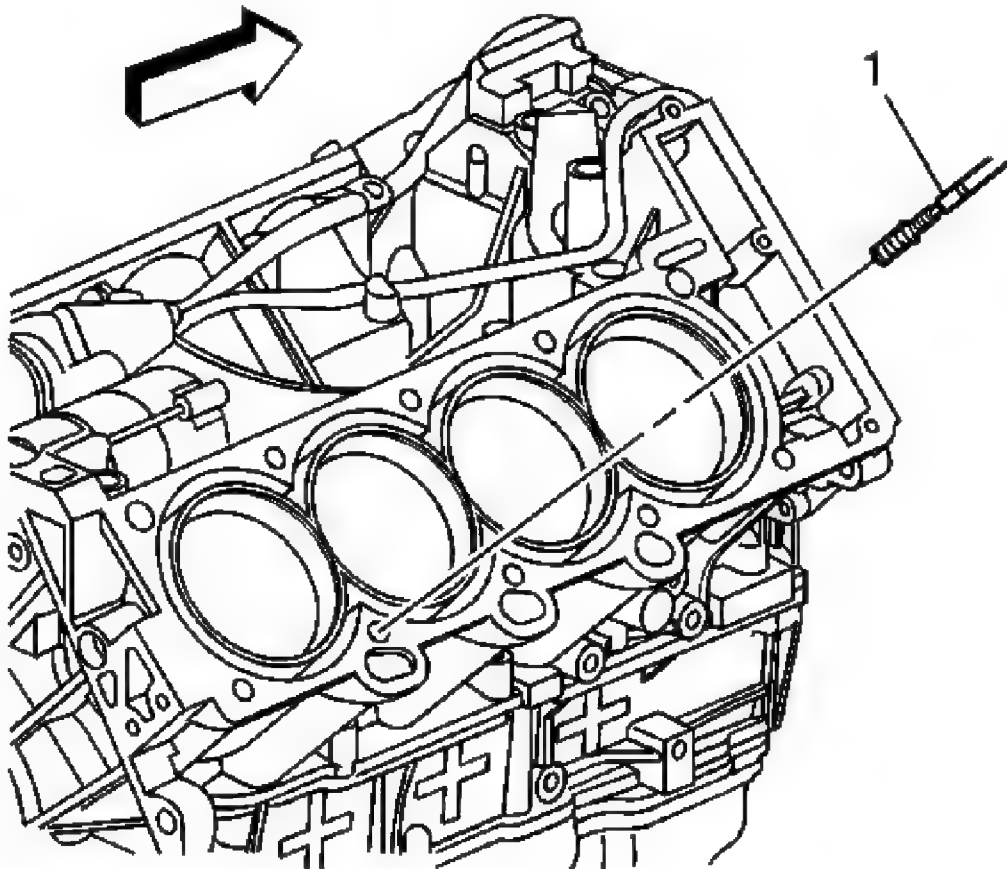


Fig. 246: Installing Insert & Installation Driver - Outboard Bolt Holes
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and installation driver (1) into the tapped hole by hand only.
19. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

IMPORTANT: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and

the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.
22. Inspect the insert for proper installation into the tapped hole.

CRANKSHAFT MAIN BOLT HOLE THREAD REPAIR

Tools Required

J 42385-2000 Thread Insert Kit. See Special Tools .

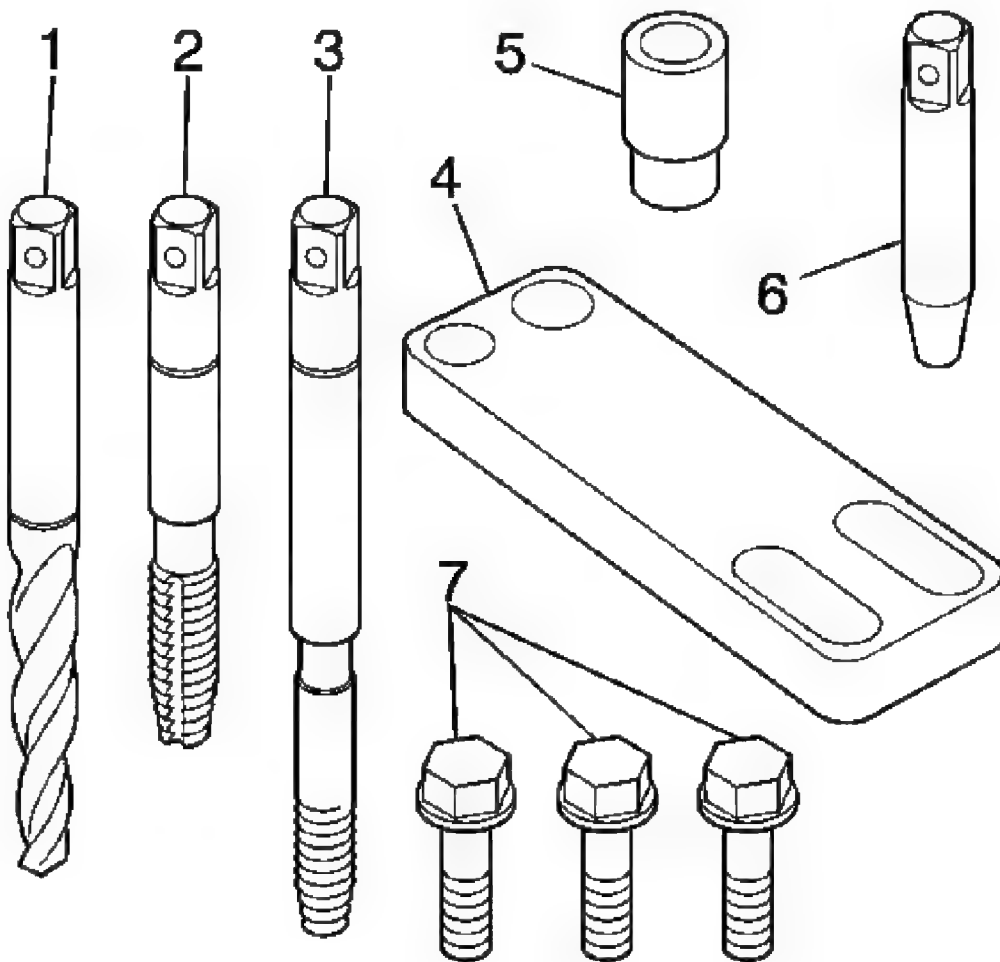


Fig. 247: Identifying Crankshaft Main Bearing Bolt Hole Thread Repair Kit J 42385-2000

Courtesy of GENERAL MOTORS CORP.

- IMPORTANT:**
- In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.
 - Do NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.

The crankshaft main bearing bolt hole thread repair kit **J 42385-2000** components consist of the following: See **Special Tools** .

- Drill (1) J 42385-511
- Tap (2) J 42385-512
- Installation driver (3) J 42385-513
- Fixture plate (4) J 42385-306
- Bushing (5) J 42385-307
- Alignment pin (6) J 42385-308
- Bolts (7) J 42385-510

CAUTION: Refer to **Safety Glasses Caution** .

- IMPORTANT:**
- Ensure the fixture plate is installed during the machining and installation processes of the insert.
 - The use of a cutting type fluid GM P/N 1052864, (Canadian P/N 992881), WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

Thread Repair Procedure

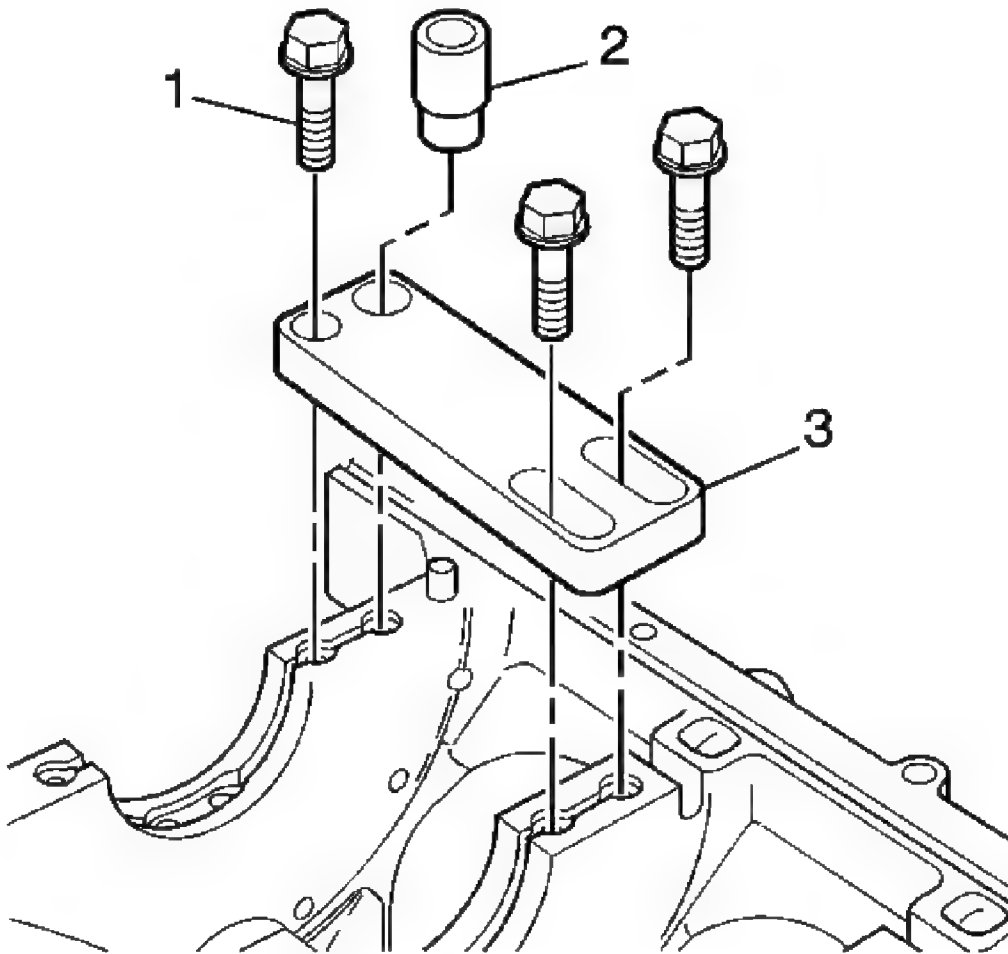


Fig. 248: View Of Fixture Plate & Components - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

1. Position the fixture plate (3) with the bushing (2), installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.

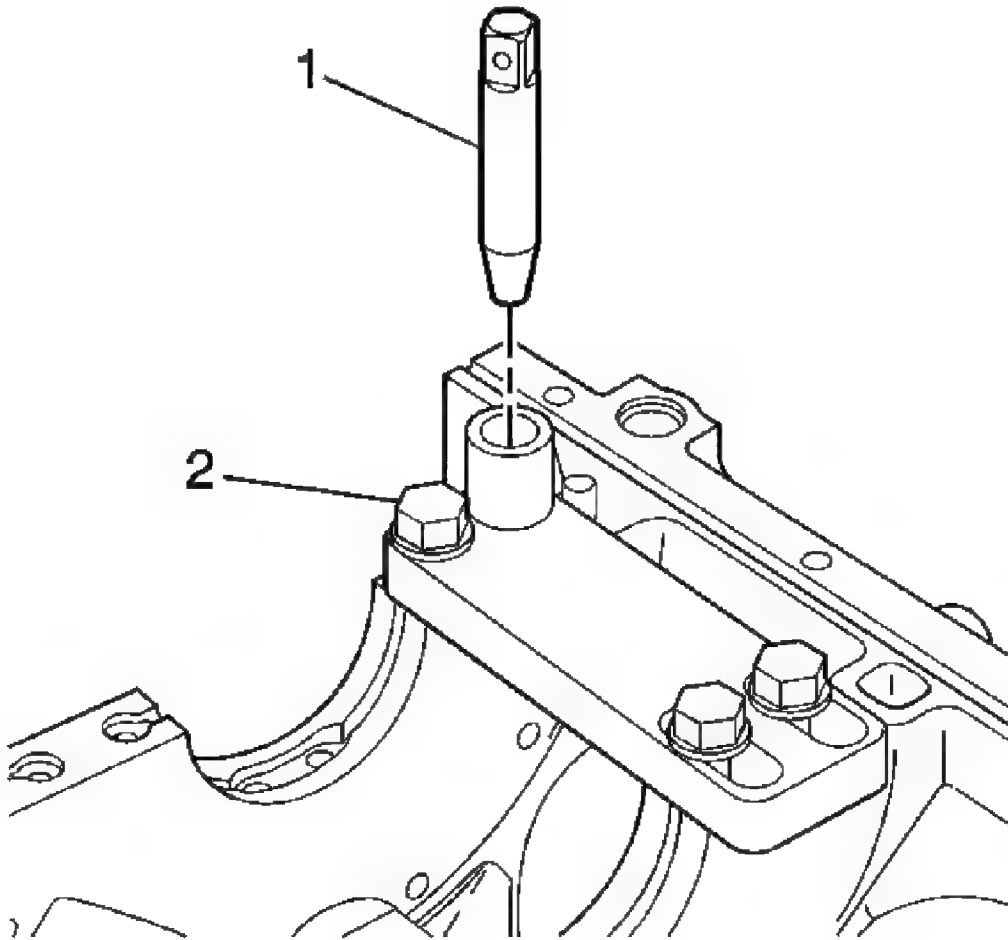


Fig. 249: Positioning Alignment Pin - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.
4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

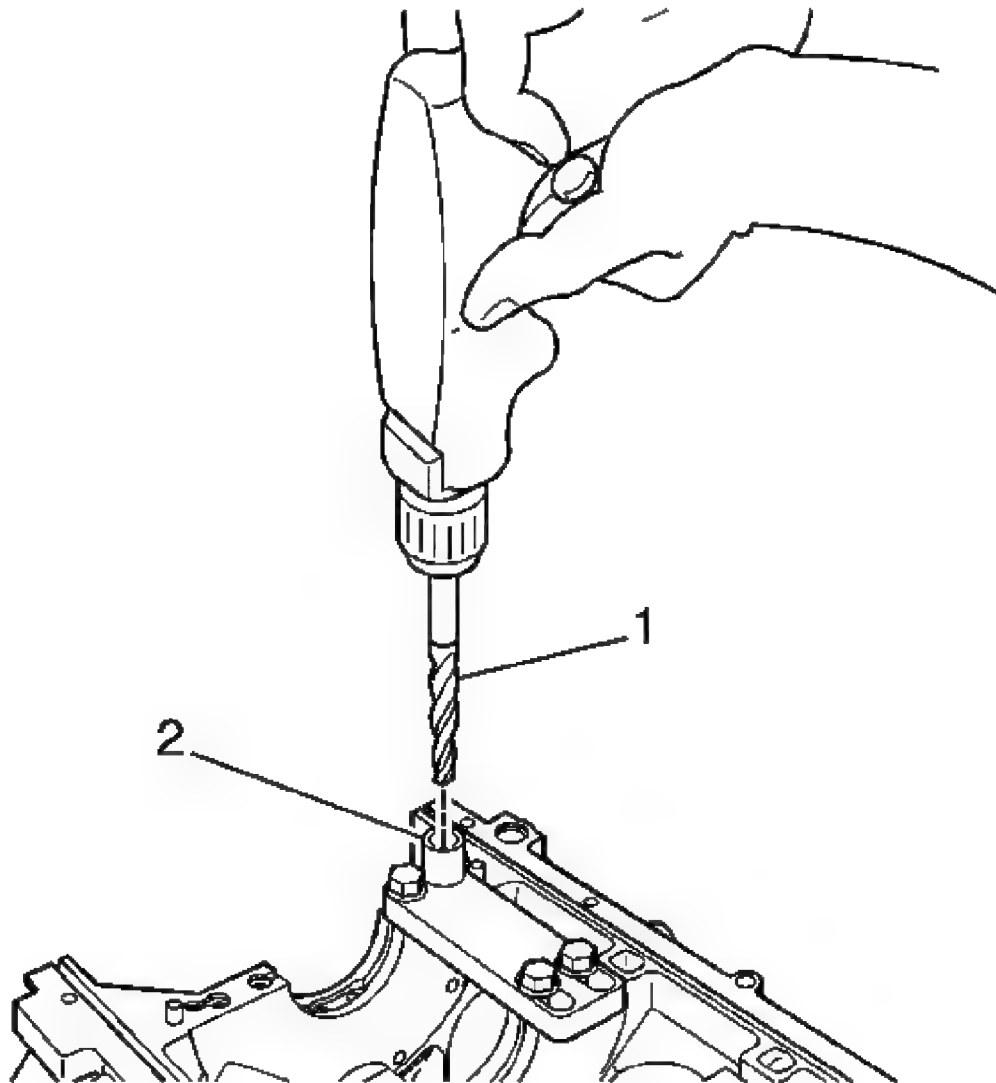


Fig. 250: Drilling Out Threads Of Damaged Hole - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

6. Drill out the threads of the damaged hole.

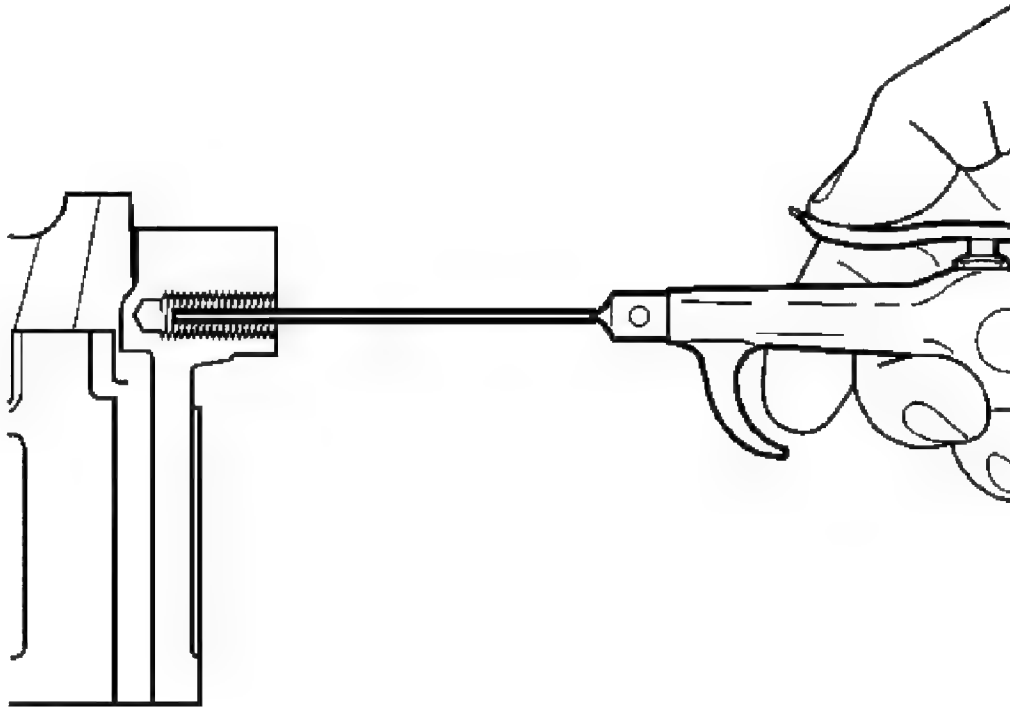


Fig. 251: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

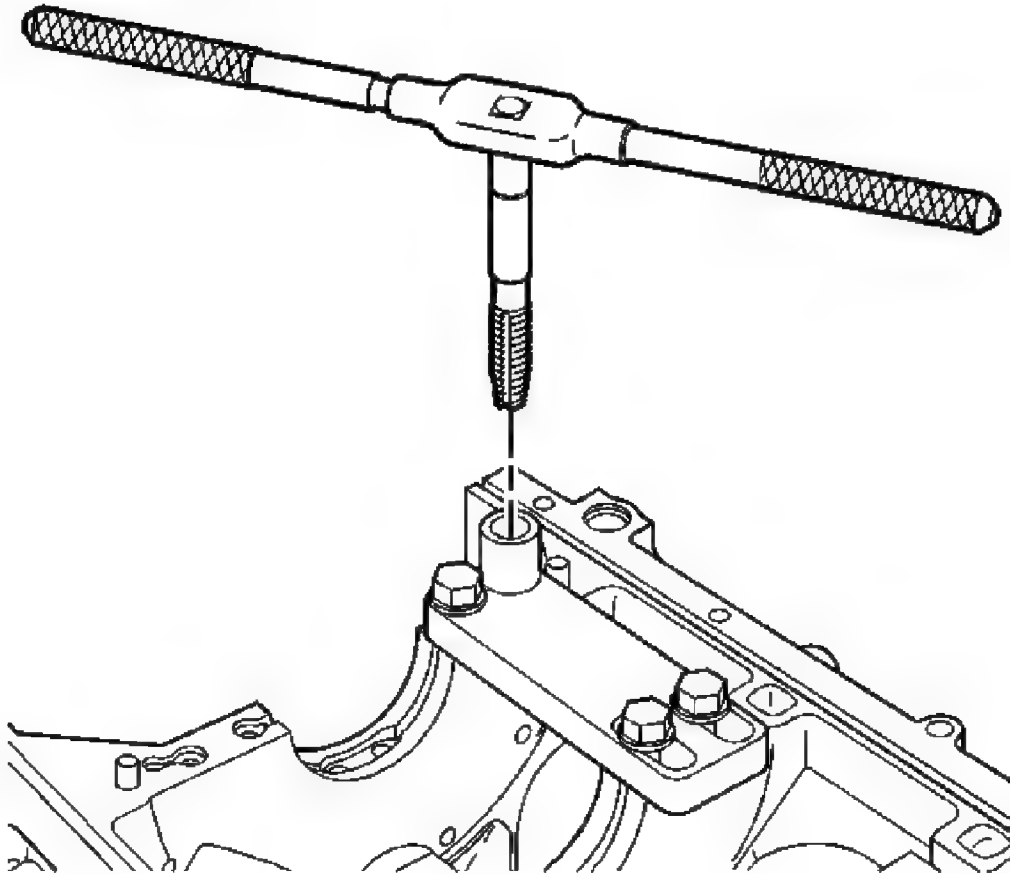


Fig. 252: Tapping Threads Using Tapping Wrench - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.

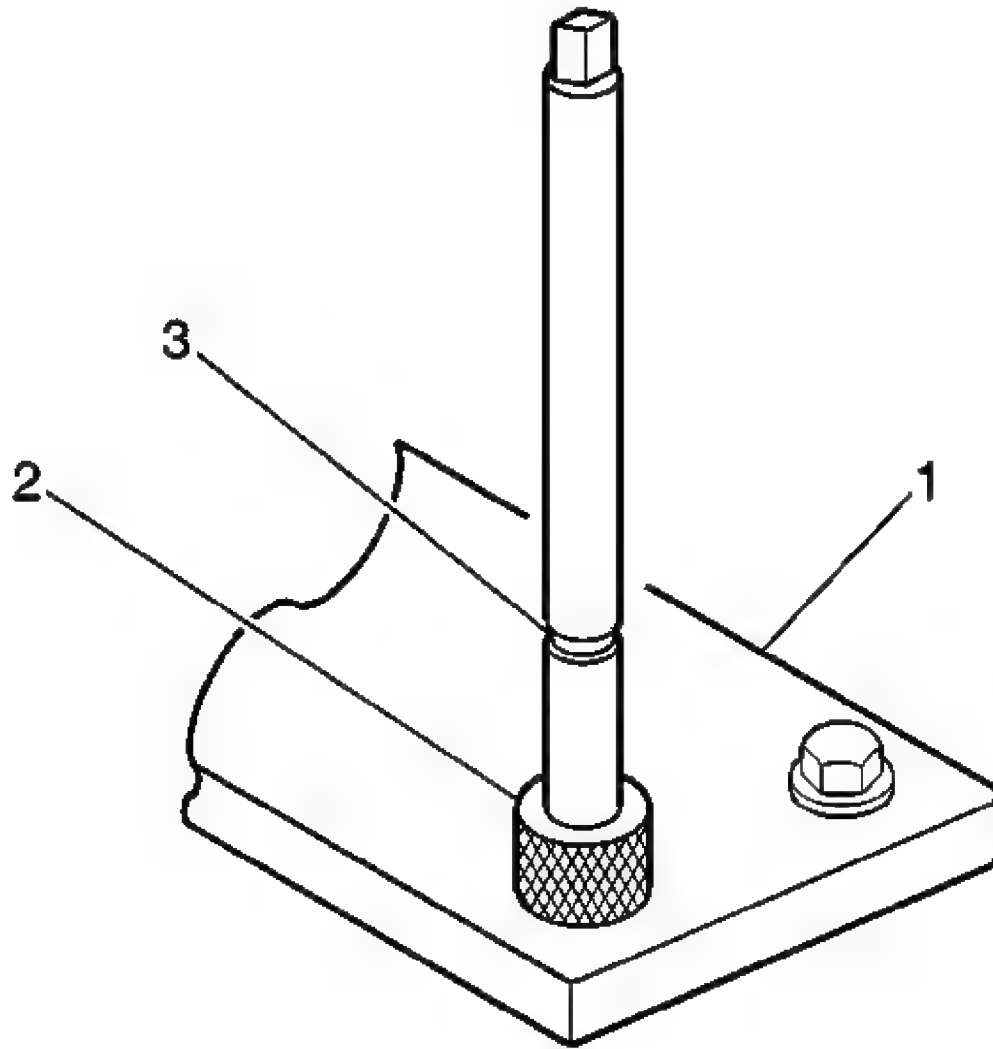


Fig. 253: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

9. In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2).

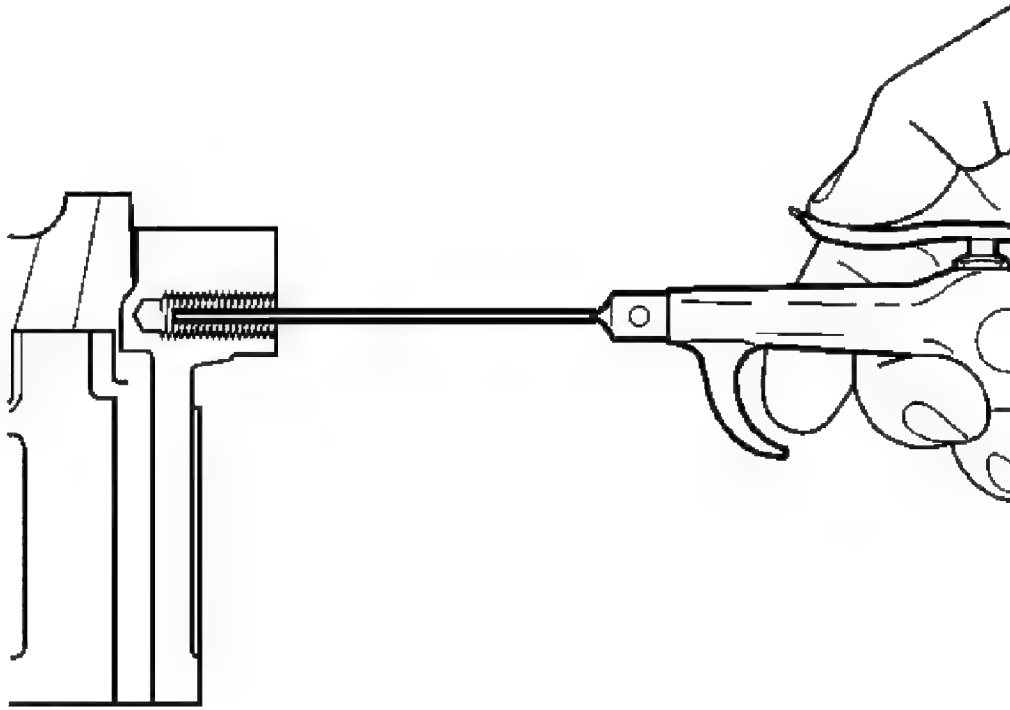


Fig. 254: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.

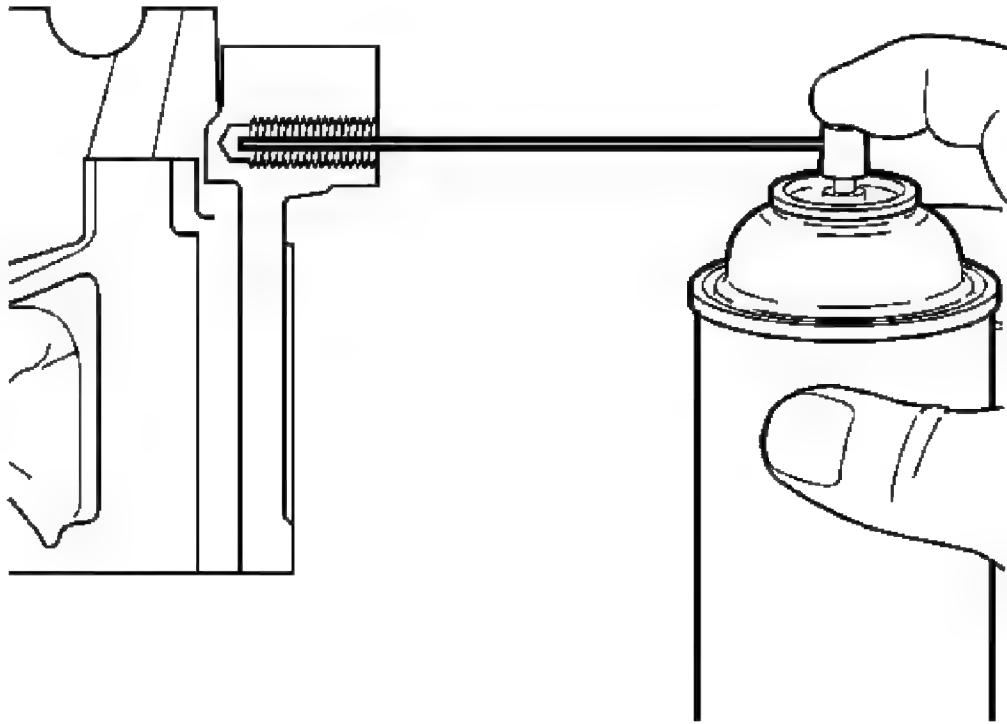


Fig. 255: Spraying Cleaner Into Tapped Hole
Courtesy of GENERAL MOTORS CORP.

11. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the tapped hole.

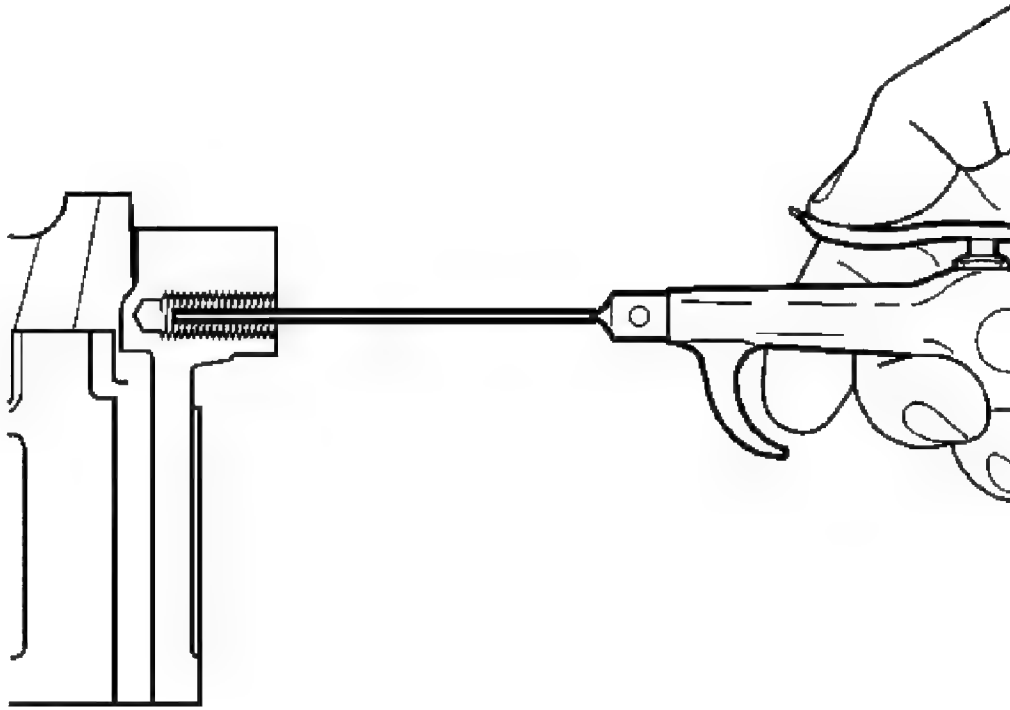


Fig. 256: Cleaning Out Metal Chips
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

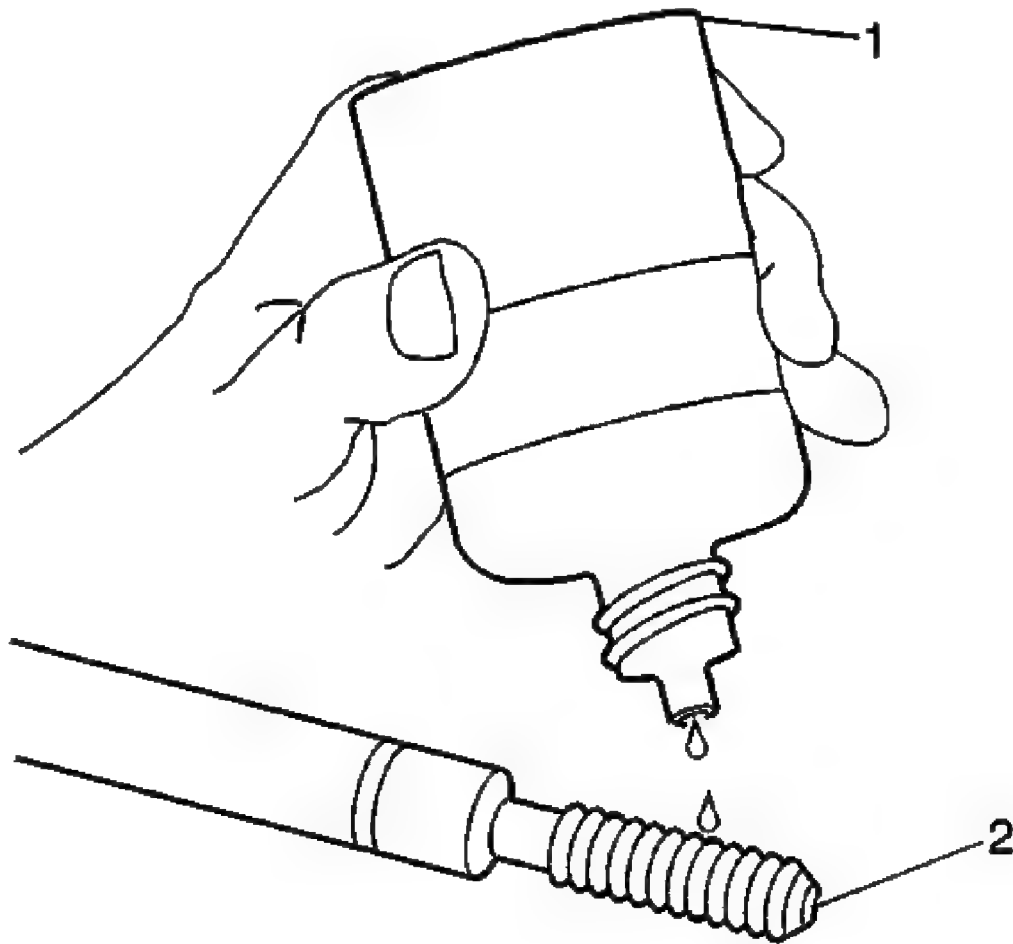


Fig. 257: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- Do not remove the fixture plate, ensure the fixture plate is installed during the installation process of the insert.
- Do not allow oil or other foreign material to contact the OD of the insert.

13. Lubricate the threads of the driver installation tool (2) with the driver oil J 42385-110 (1).

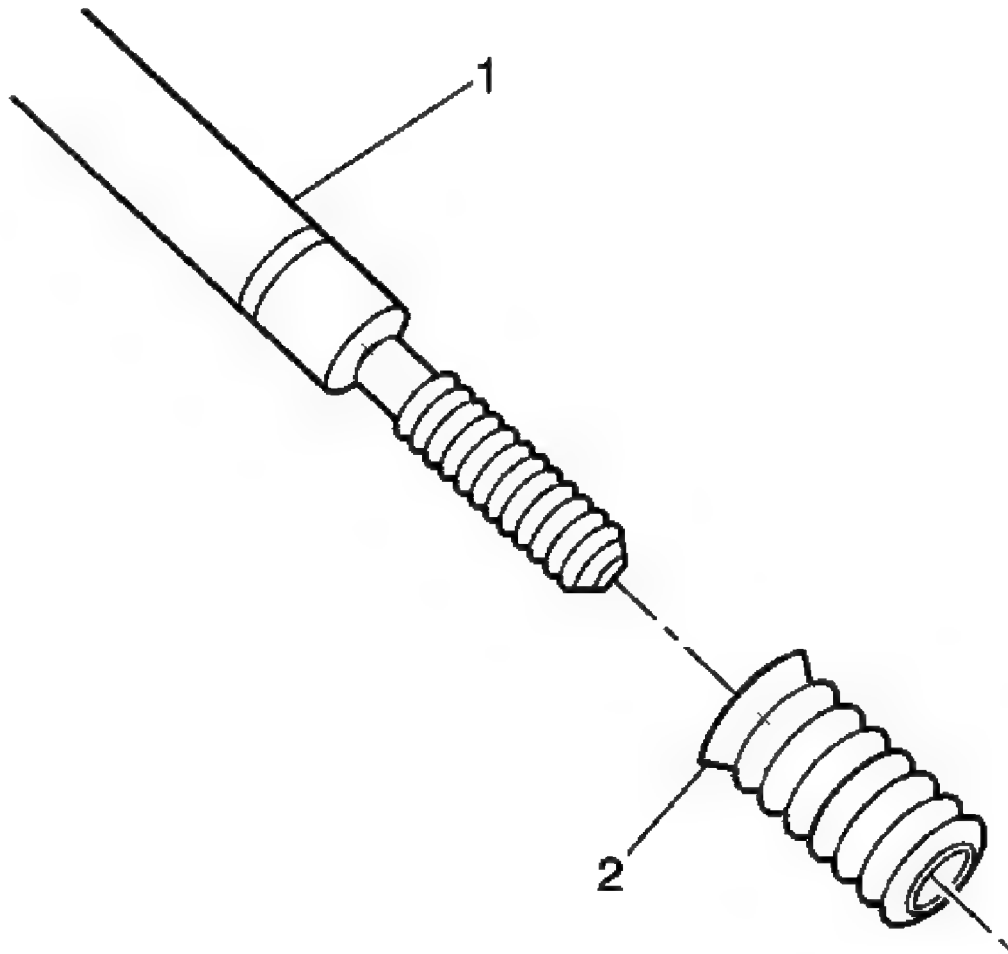


Fig. 258: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

14. Install the insert (2) onto the driver installation tool (1).

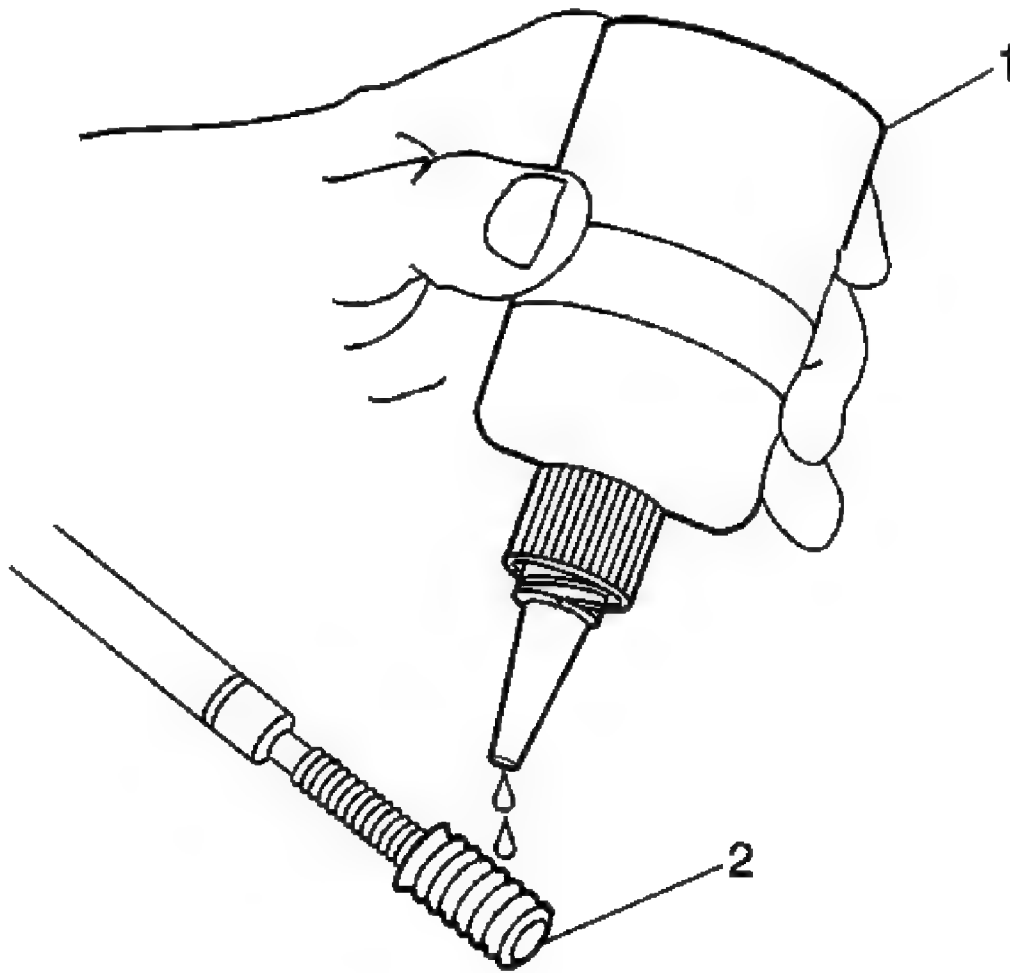


Fig. 259: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

15. Apply threadlock sealant GM P/N 12345493, (Canadian P/N 10953488), J 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2).

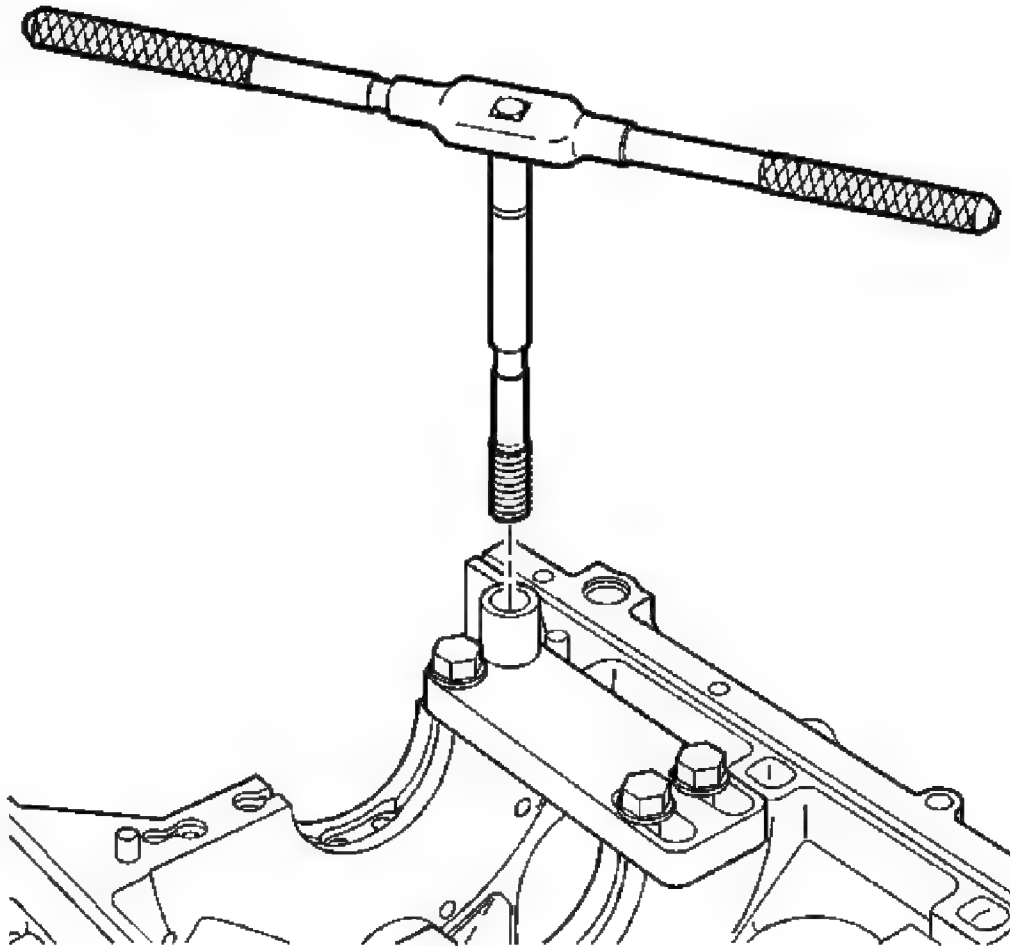


Fig. 260: Installing Insert & Installation Driver - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

16. Install the insert and installation driver into the tapped hole by hand only.
17. Start the insert into the threaded hole.

IMPORTANT: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or improper tapping.

18. Install the insert until the flange of the insert contacts the counterbored surface.

IMPORTANT: The driver installation tool will tighten up before screwing

completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool through the insert.

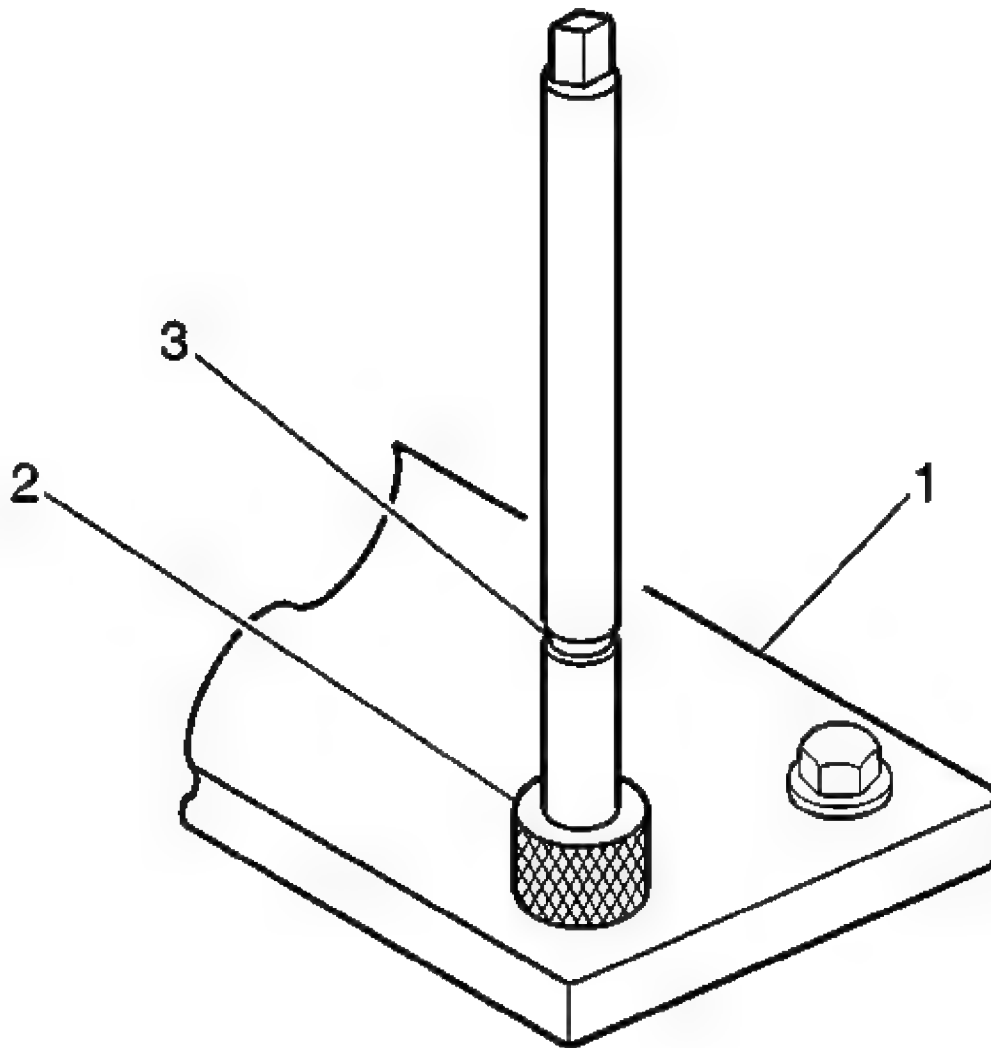


Fig. 261: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

20. Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2).

21. Inspect the insert for proper installation into the tapped hole.

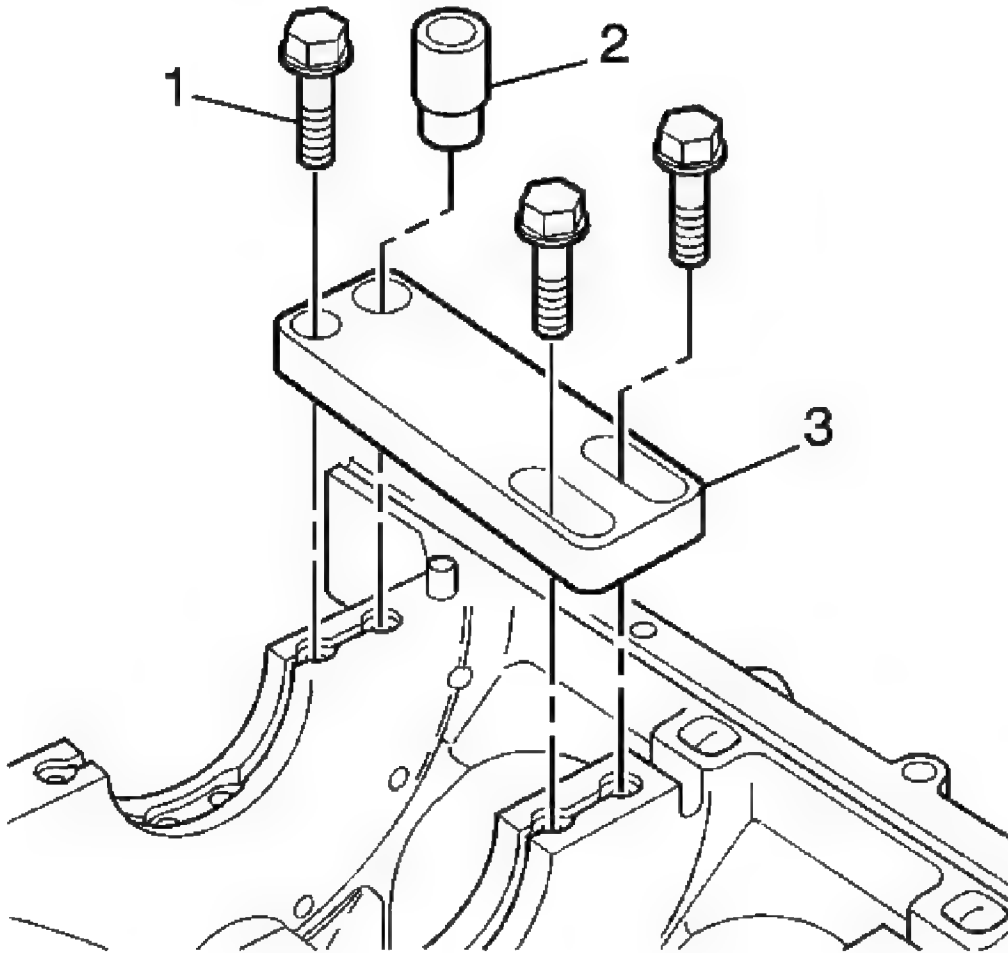


Fig. 262: View Of Fixture Plate & Components - Crankshaft Main Bolt Hole
Courtesy of GENERAL MOTORS CORP.

22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

SERVICE PRIOR TO ASSEMBLY

SERVICE PROCEDURE

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.

- When the components are reinstalled into an engine, return the components to their original location, position and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

ENGINE BLOCK ASSEMBLE - UPPER

ASSEMBLY PROCEDURE

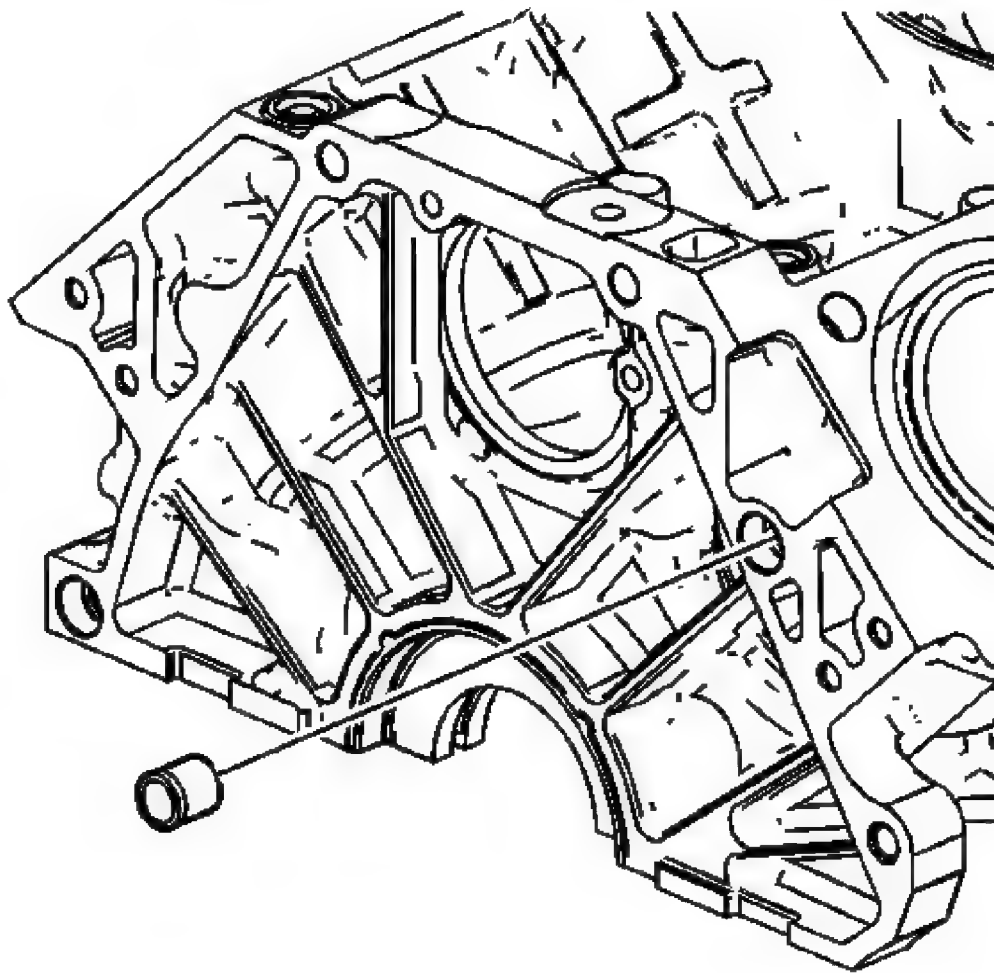


Fig. 263: View Of Transaxle Locating Dowels
Courtesy of GENERAL MOTORS CORP.

1. Install the transaxle locating dowels.

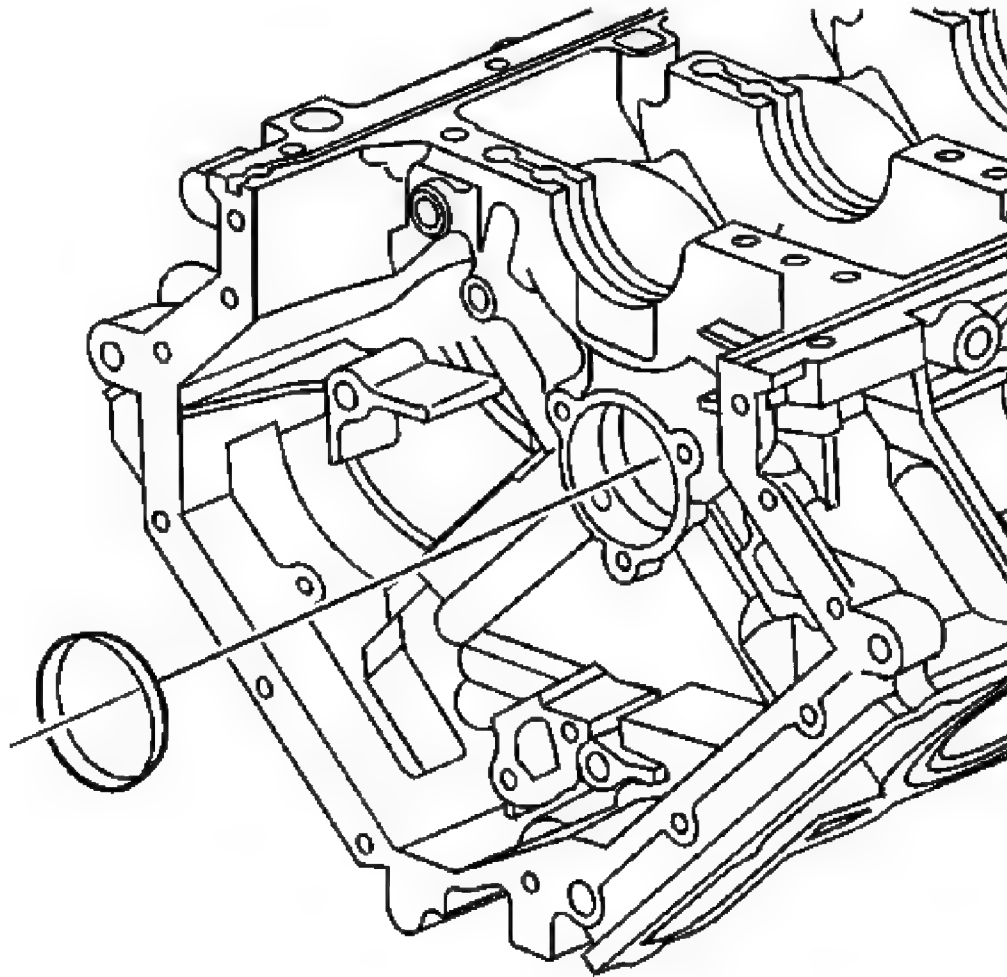


Fig. 264: View Of Camshaft Intermediate Shaft Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: Proper installation of the camshaft intermediate shaft plug must be ensured. An improperly installed camshaft intermediate shaft plug can interfere and restrict oil flow to the cylinder heads if installed too shallow and may interfere with the crankshaft if installed too deep. Failure to properly install the camshaft intermediate shaft plug can lead to engine damage.

2. Install the camshaft intermediate shaft plug.

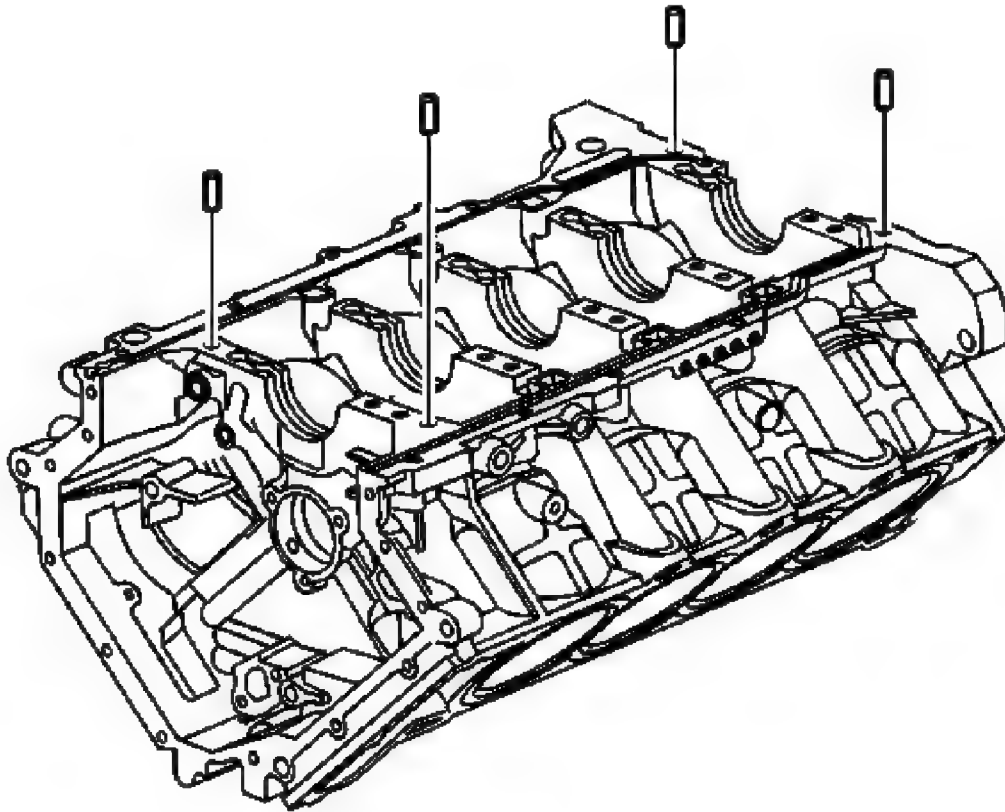


Fig. 265: Identifying Lower Crankcase Locating Dowel Pins
Courtesy of GENERAL MOTORS CORP.

3. Install the lower crankcase locating dowel pins.

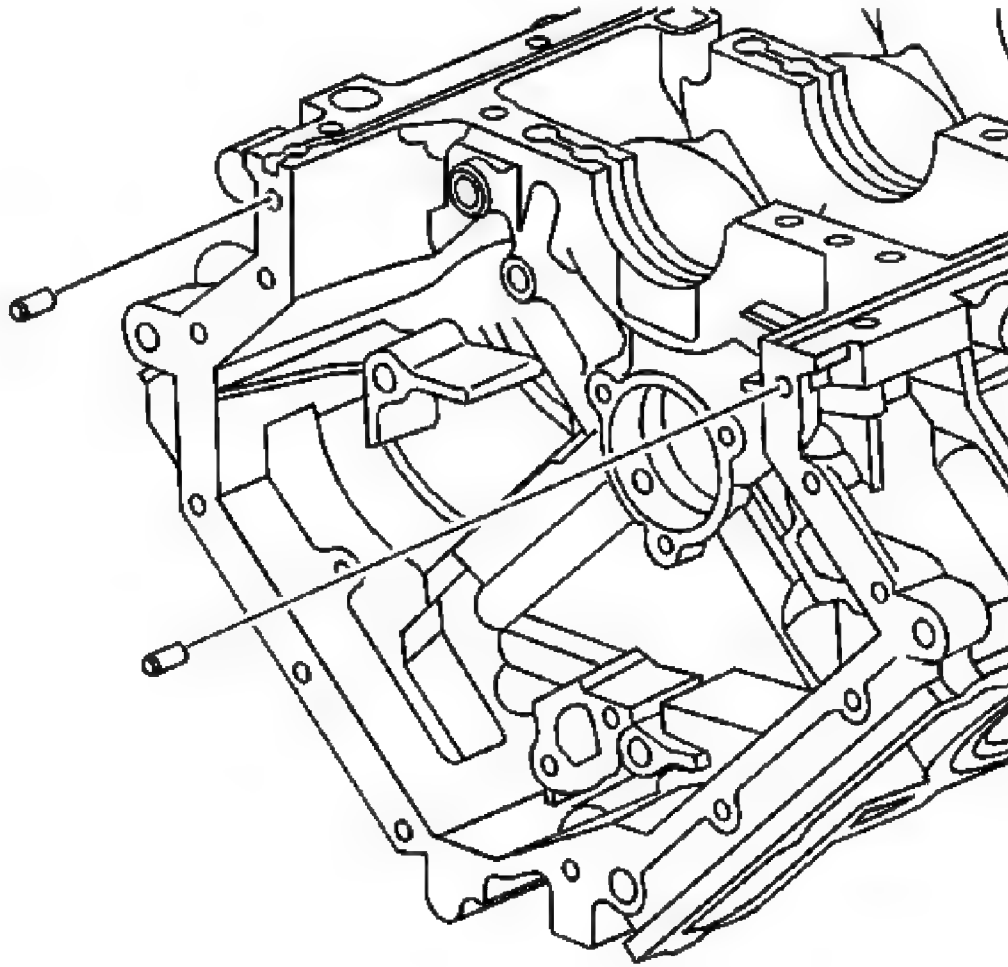


Fig. 266: Identifying Engine Front Cover Dowel Pins
Courtesy of GENERAL MOTORS CORP.

4. Install the engine front cover dowel pins.

CRANKSHAFT AND BEARING INSTALLATION

CRANKSHAFT BEARING INSTALLATION PROCEDURE

Tools Required

J 45059 Angle Meter

Installation Procedure

IMPORTANT: If the crankshaft bearings have been used in a running engine, you must replace them with **NEW** crankshaft bearings for reassembly.

1. Clean the upper and lower crankcase crank bore with a lint-free cloth.

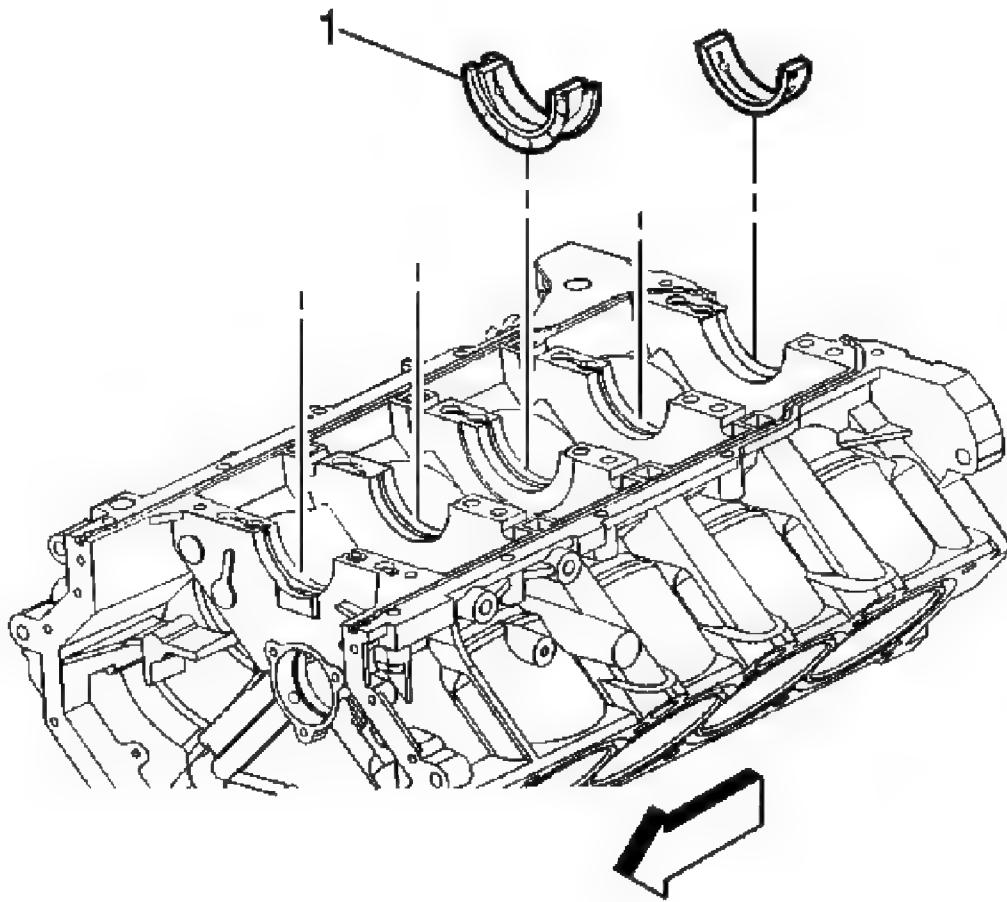


Fig. 267: View Of Thrust Bearing
Courtesy of GENERAL MOTORS CORP.

2. Clean all the oil from the backside of new bearing halves.
3. Install new upper crankshaft bearings into position. The thrust bearing (1) belongs in the number three journal. Be sure the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.

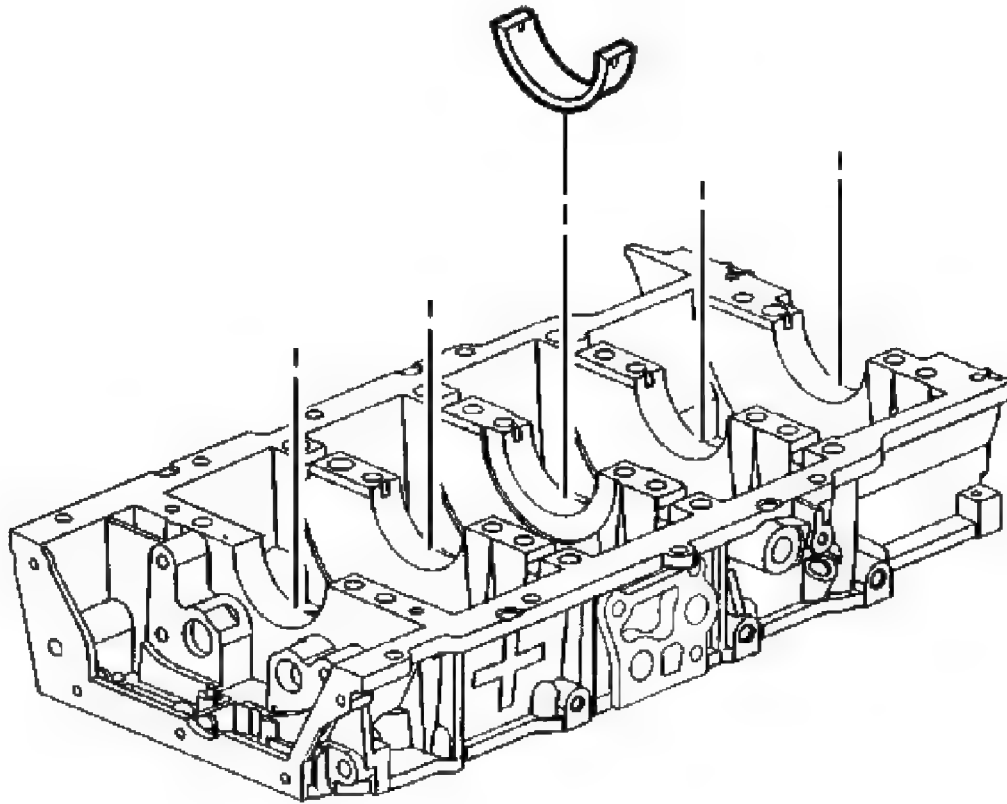


Fig. 268: View Of Lower Main Bearing Halves
Courtesy of GENERAL MOTORS CORP.

4. Install new lower crankshaft bearings into position in the lower crankcase. The lower crankcase crankshaft bearings are identified by NO grooves or holes. The bearings must fit flush with the lower crankcase.
5. Apply a liberal amount of GM crankshaft prelube GM P/N 1052367, (Canadian P/N 992869) or engine oil to the upper and lower bearing surfaces.

CRANKSHAFT INSTALLATION PROCEDURE

Installation Procedure

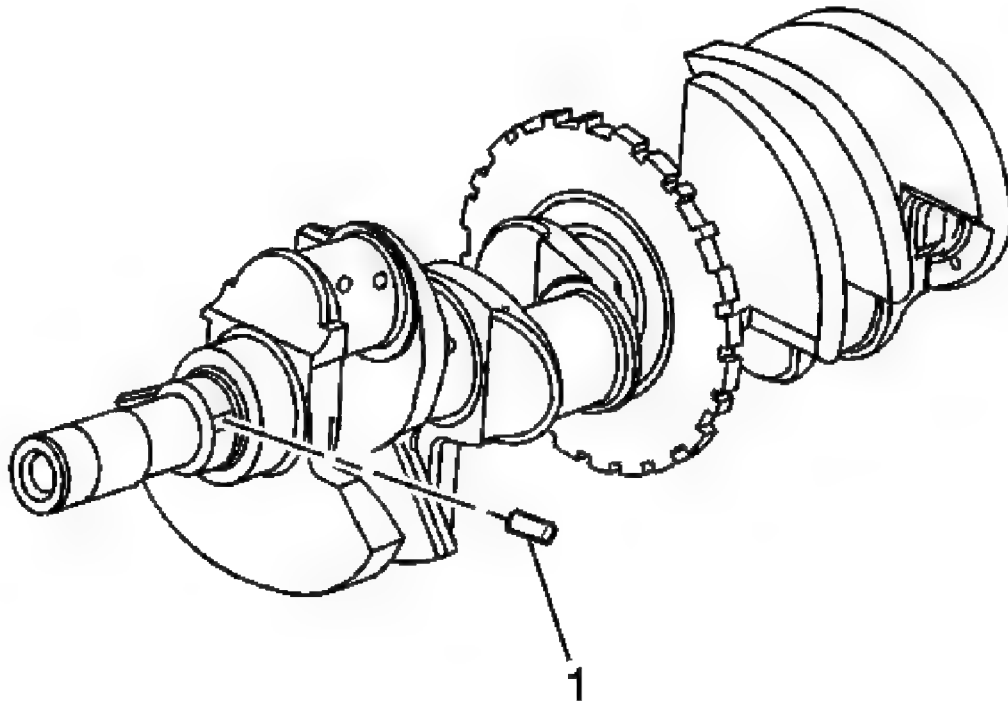


Fig. 269: View Of Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft sprocket drive pin (1).

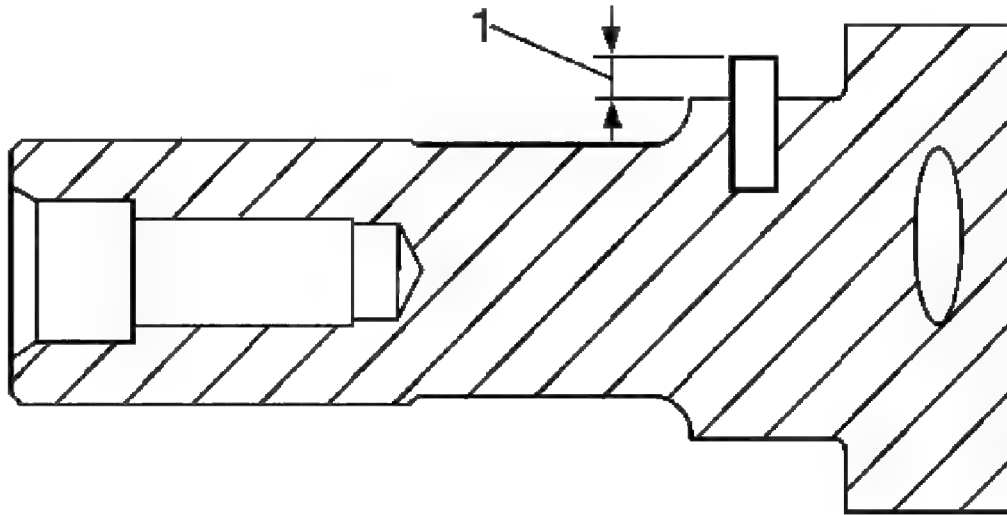


Fig. 270: Ensuring Proper Pin Height
Courtesy of GENERAL MOTORS CORP.

2. Ensure pin height (1) is 2.75-3.25 mm (0.0689-0.1280 in).

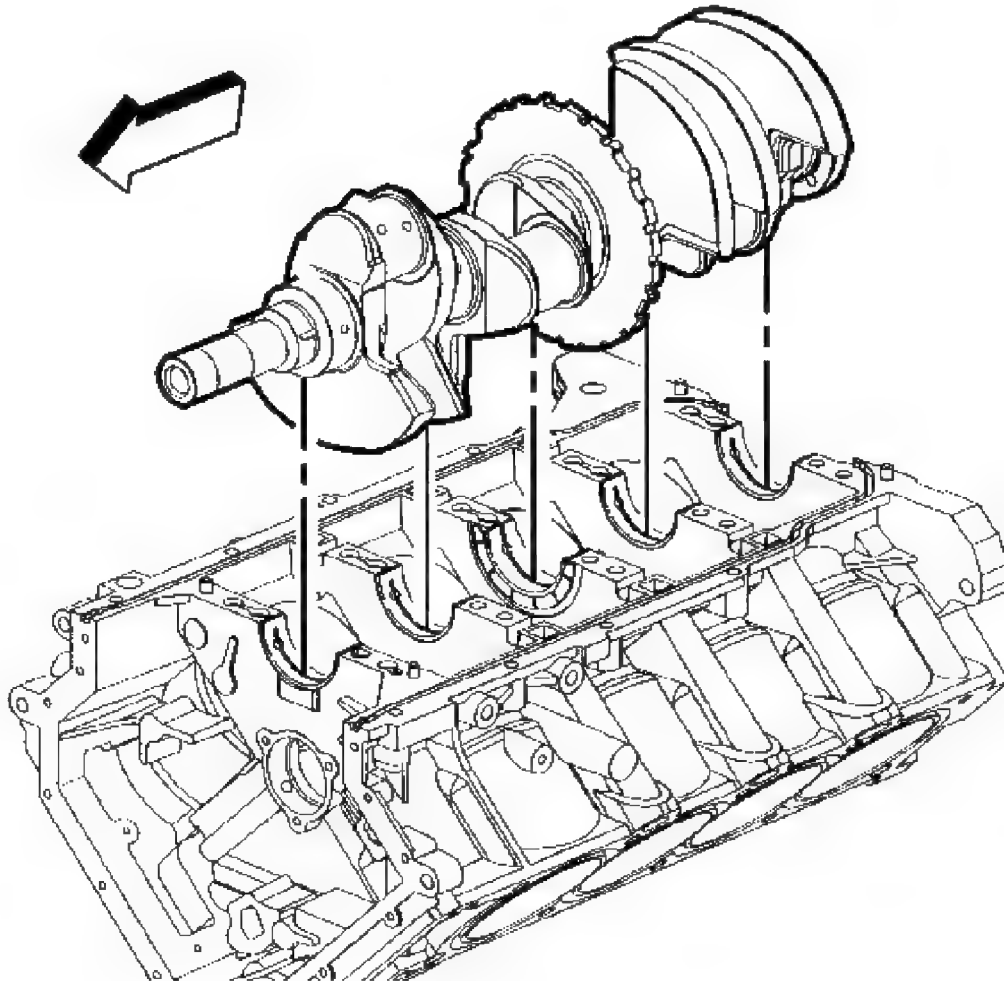


Fig. 271: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

3. Gently lower the crankshaft into position in the cylinder block.
4. Make sure the crankshaft turns without binding or noise.

CRANKSHAFT BEARING CLEARANCE MEASUREMENT PROCEDURE

Measurement Procedure

1. Place a length of fresh, room temperature plastic gaging material all the way across all the crankshaft bearing journals.

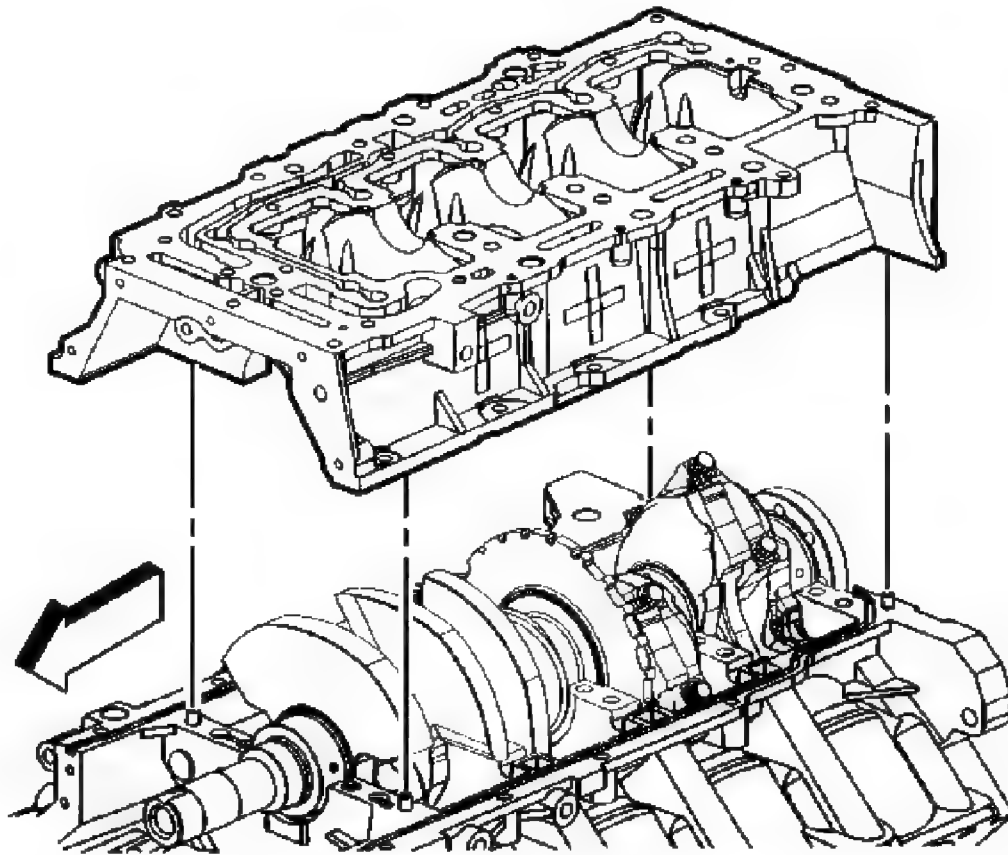


Fig. 272: View Of lower Crankcase
Courtesy of GENERAL MOTORS CORP.

2. Align the lower crankcase with the dowel pins in the upper crankcase.
3. Install the lower crankcase onto the upper crankcase slowly until feeling a positive stop.
4. Inspect the upper-to-lower crankcase joint in order to make sure the lower crankcase is fully seated on the cylinder block.

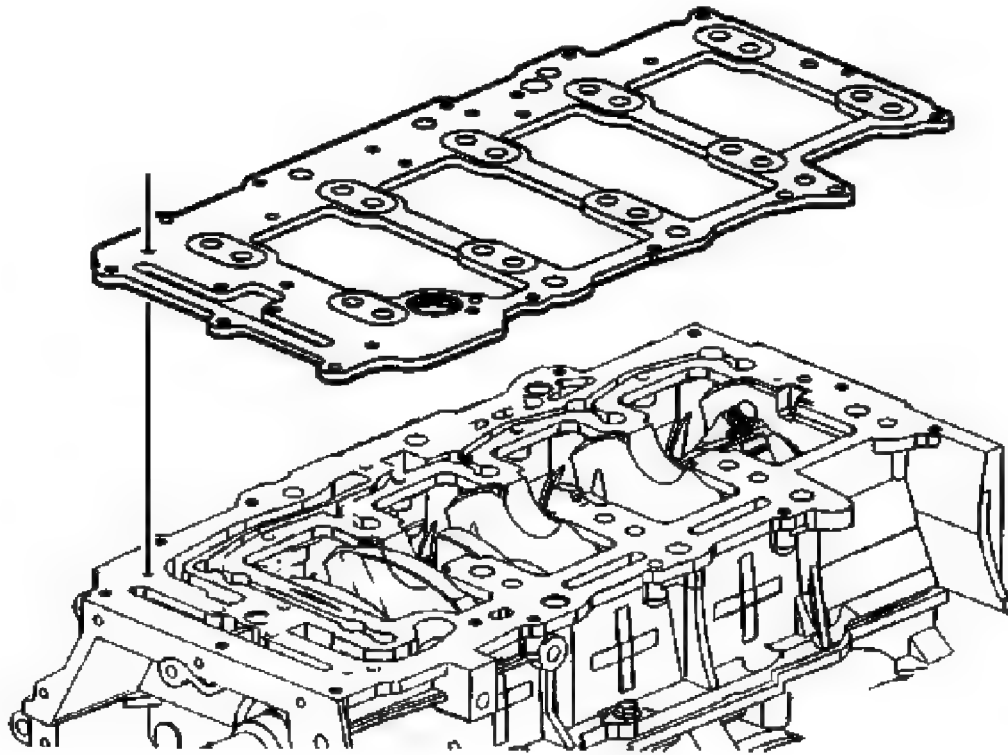


Fig. 273: View Of Oil Manifold Plate
Courtesy of GENERAL MOTORS CORP.

5. Install the oil manifold plate.

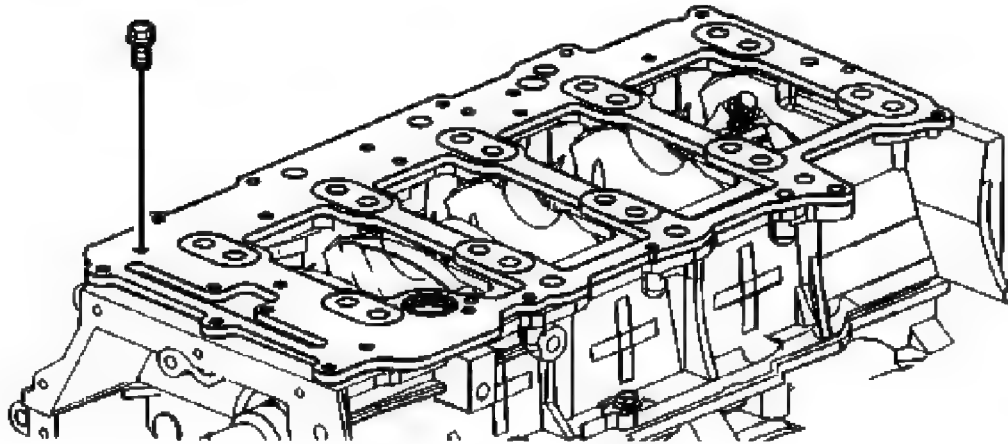


Fig. 274: Identifying Oil Manifold Plate Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the oil manifold plate retaining bolts.

Tighten: Tighten the oil manifold plate bolts to 10 N.m (89 lb in).

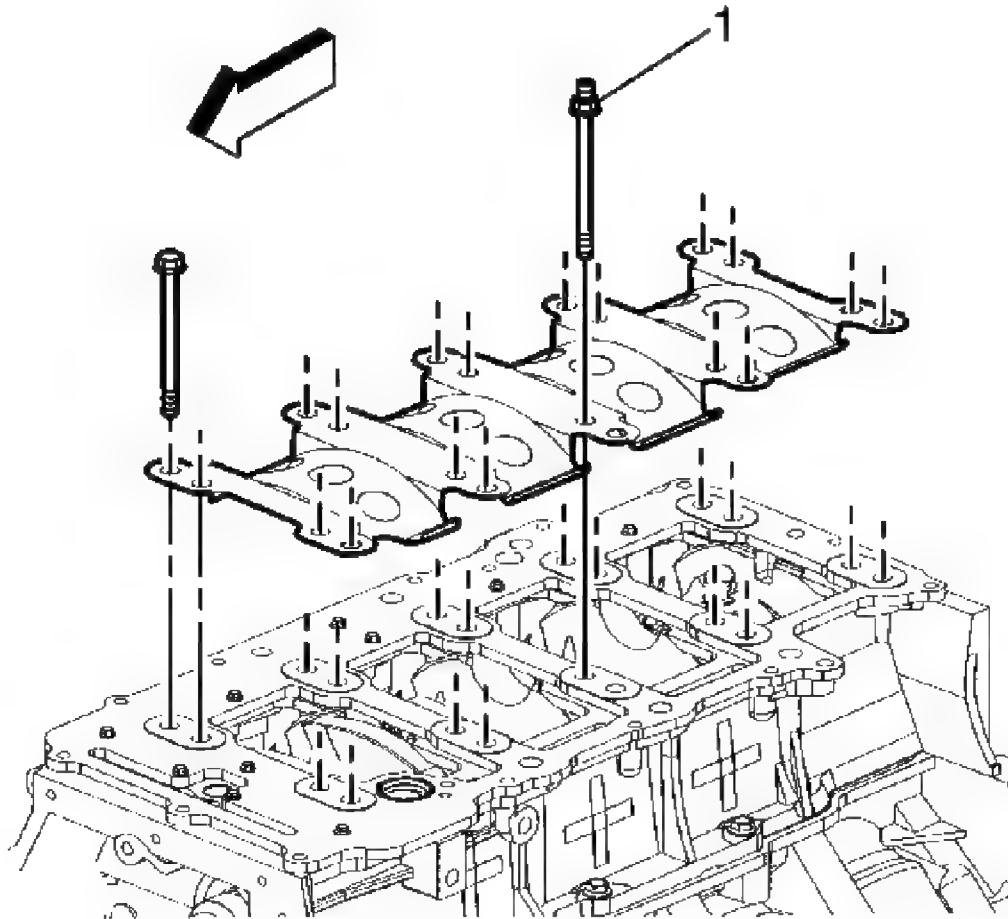


Fig. 275: Identifying Stud-End Bolt
Courtesy of GENERAL MOTORS CORP.

7. Place the crankshaft oil scraper in position on the oil manifold. Align the holes with the main bearing bolt holes.
8. Install the main bearing bolts. The single stud-head bolt (1) used for oil pump pick-up mounting goes in the inboard position of the third set of main bearing bolts from the front of the engine.

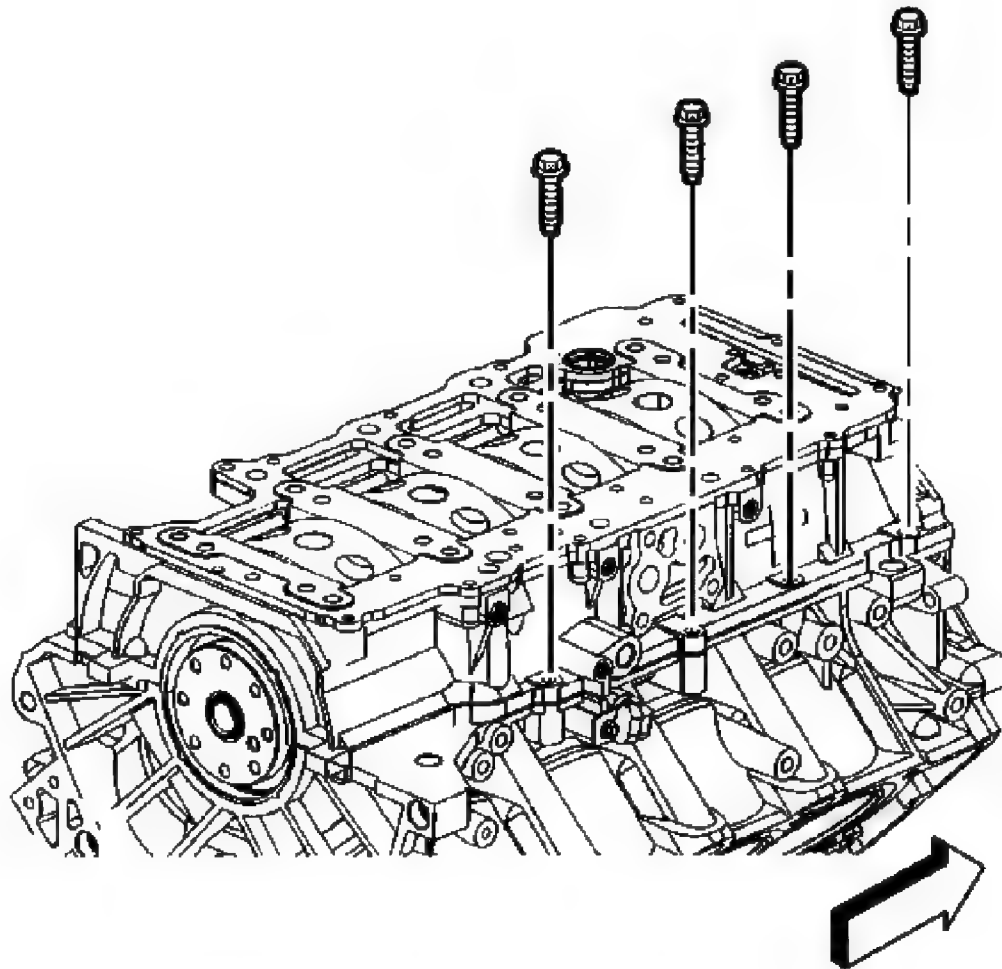


Fig. 276: Locating Left Side Upper-To-Lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the left side upper-to-lower crankcase perimeter bolts.

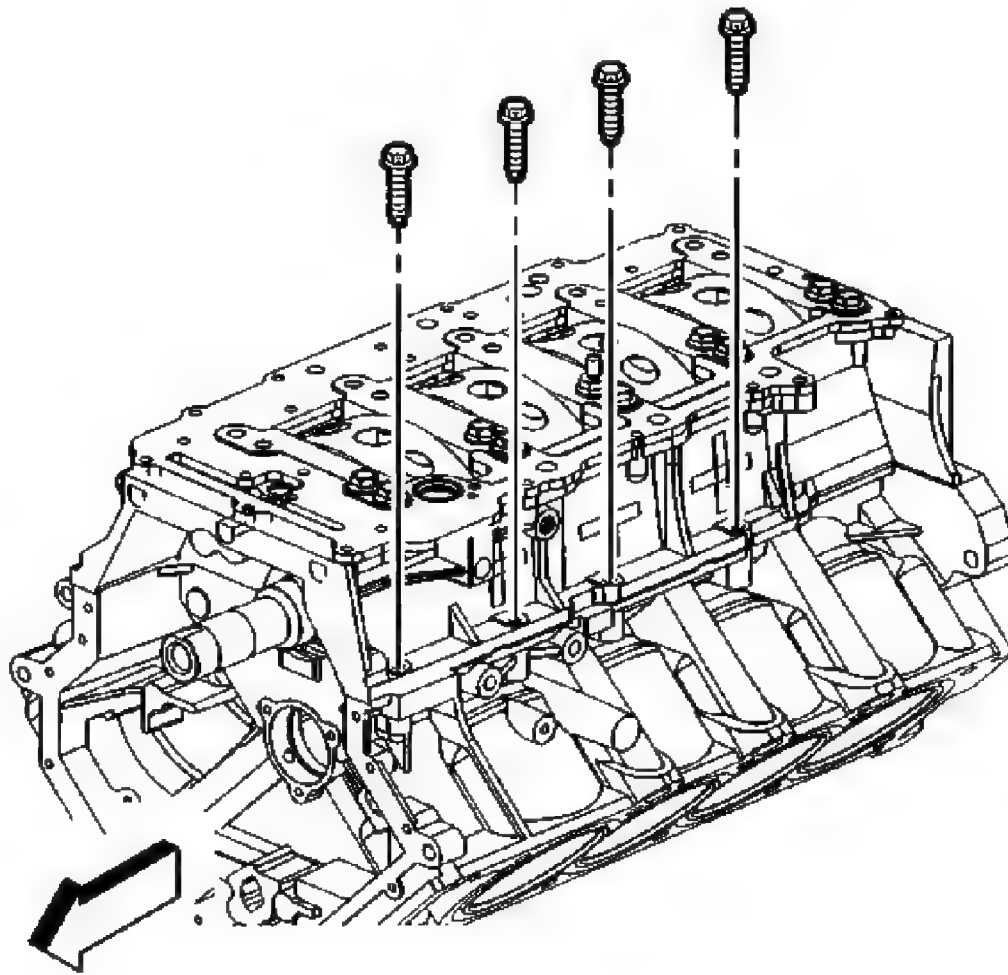


Fig. 277: Identifying Crankcase Perimeter Retaining Bolts on Right of Engine
Courtesy of GENERAL MOTORS CORP.

10. Install the right side upper-to-lower crankcase perimeter bolts.

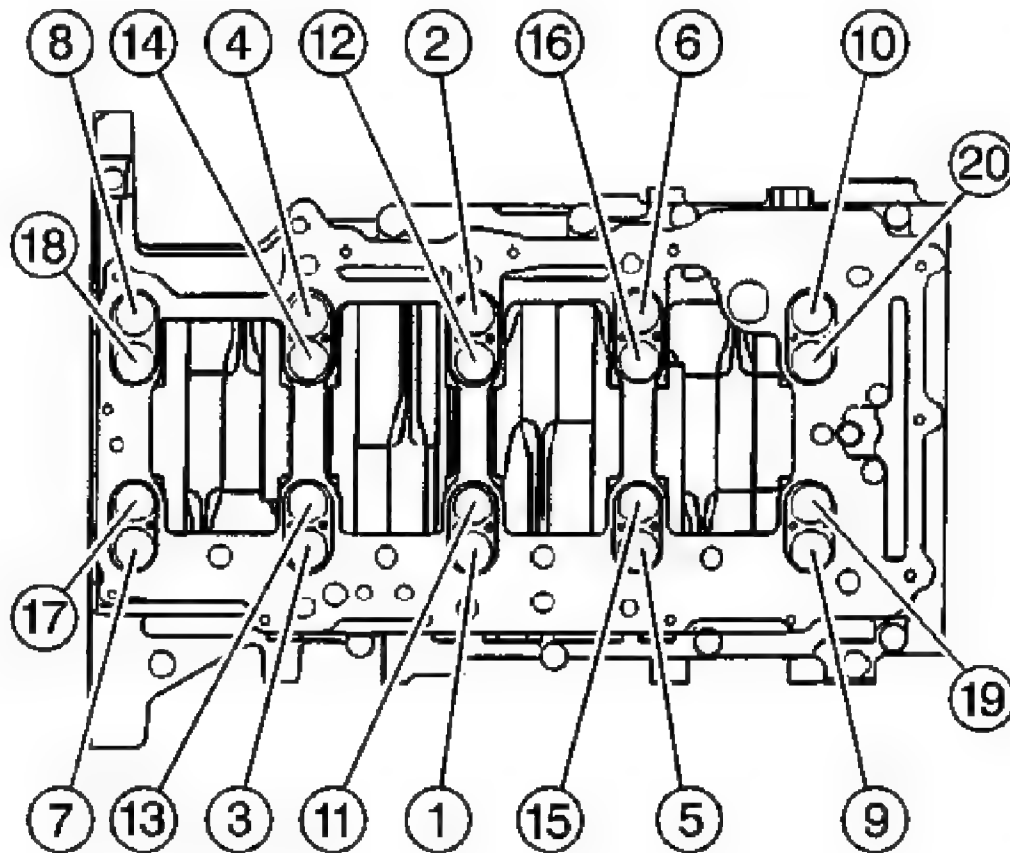


Fig. 278: Identifying Lower Crankcase Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

11. Tighten the lower crankcase bolts in proper sequence.

1. First Pass

Tighten: Tighten the lower crankcase bearing bolts (1-20) to 20 N.m (15 lb ft) in the proper sequence.

2. Final Pass

Tighten: Tighten the lower crankcase bolts (1-20) an additional 65 degrees in the proper sequence using the J 45059 .

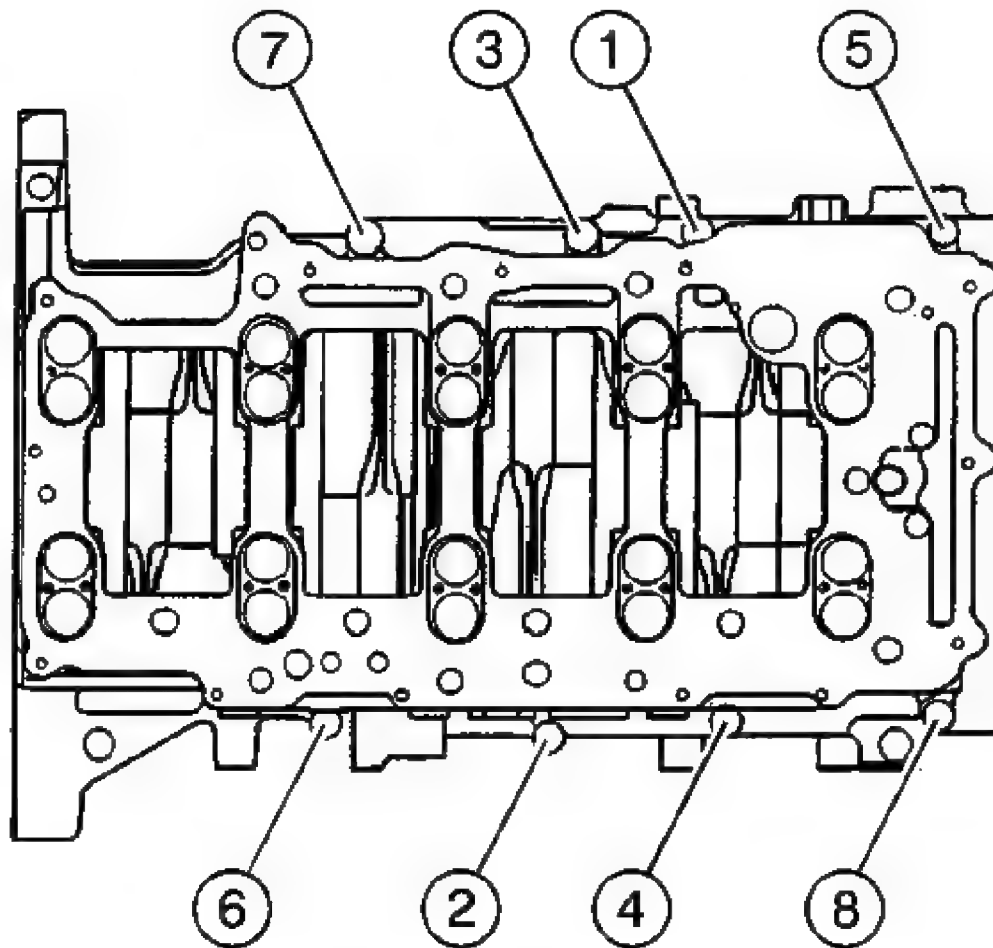


Fig. 279: Identifying Upper-To-Lower Crankcase Perimeter Bolts Tightening Sequence

Courtesy of GENERAL MOTORS CORP.

12. Tighten the upper-to-lower crankcase perimeter bolts (1-8).

Tighten: Tighten the upper-to-lower crankcase perimeter bolts (1-8) to 30 N.m (22 lb ft).

13. Allow the assembly to sit for at least two minutes.
14. Remove the main bearing bolts.
15. Remove the oil scraper.
16. Remove the oil manifold retaining bolts and oil manifold.
17. Remove the lower crankcase.

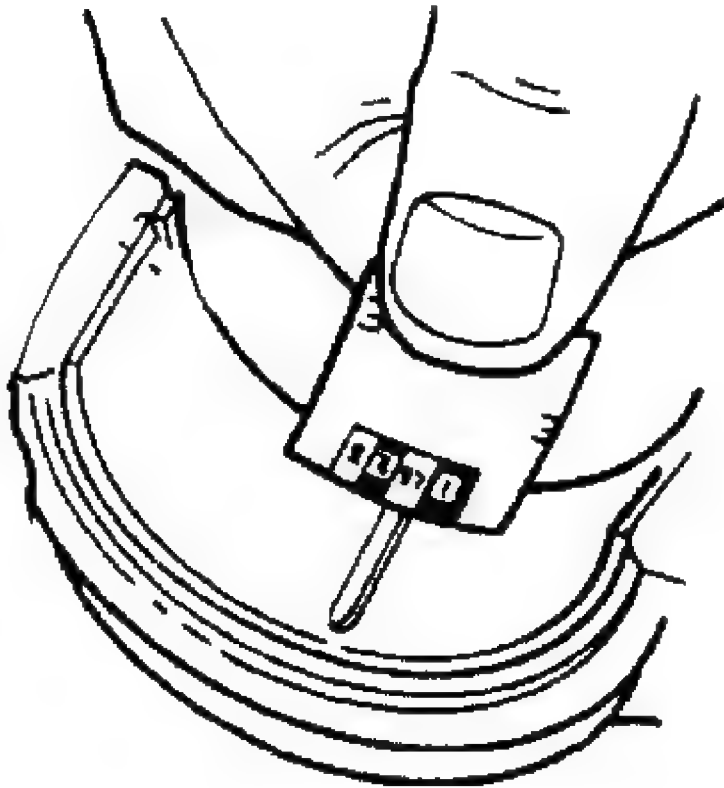


Fig. 280: Measuring Plastigage
Courtesy of GENERAL MOTORS CORP.

18. Determine the main bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container.
19. Compare your measurements with the engine mechanical specifications. If the new bearings do not provide the proper crankshaft to bearing clearance, re-measure the crankshaft journals for the correct specified size and check to make sure you have the correct new bearings. If the crankshaft journals are incorrectly sized, replace the crankshaft. No crankshaft machining is permitted and undersized bearings are not available.
20. Clean the plastic gaging material from the crankshaft bearings and/or crankshaft bearing journals using a soft lint-free cloth.
21. Coat the upper crankshaft bearings and crankshaft main bearing journals with GM crankshaft prelube GM P/N 1052367, (Canadian P/N 992869) or equivalent.

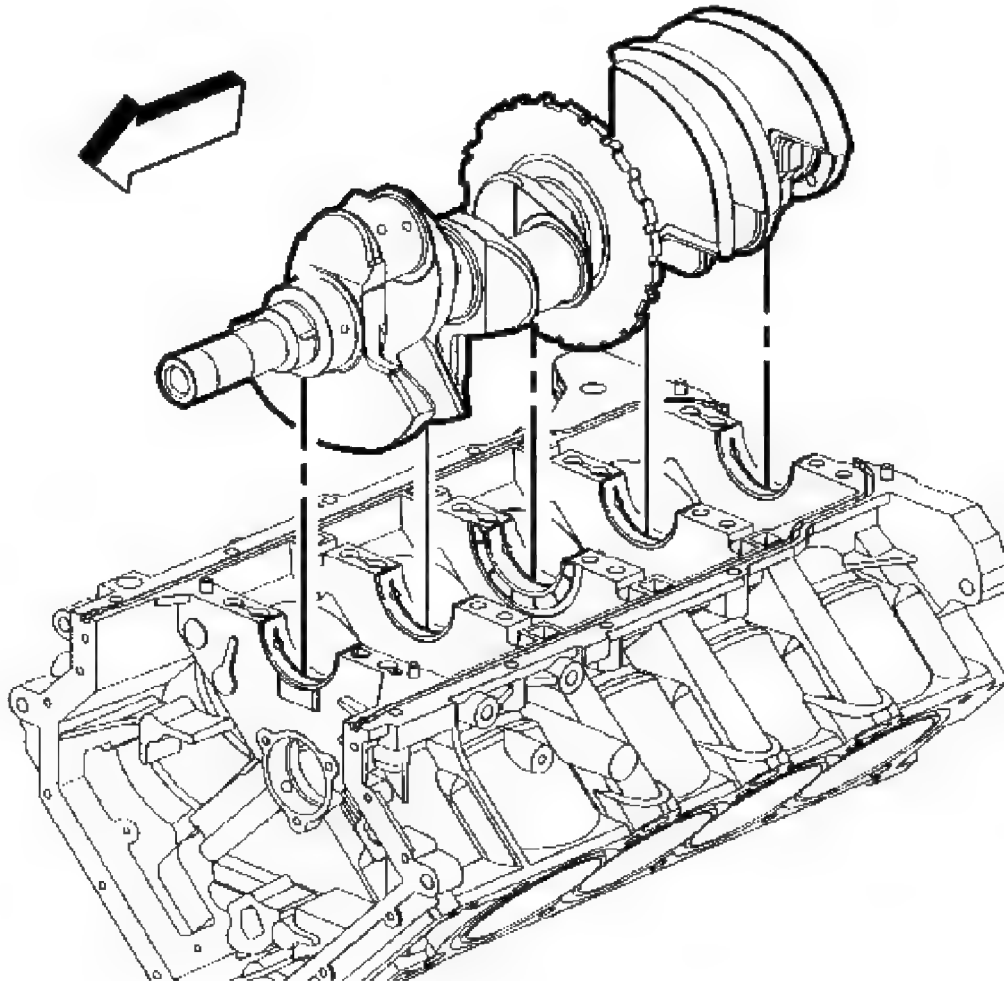


Fig. 281: View Of Crankshaft & Cylinder Block
Courtesy of GENERAL MOTORS CORP.

22. Reinstall the crankshaft into position in the cylinder block.

PISTON, CONNECTING ROD AND BEARING INSTALLATION

TOOLS REQUIRED

- **EN-47701** Piston Ring Compressor. See **Special Tools** .
- **J 39946** Crankshaft Socket. See **Special Tools** 4.6L
- **J 43690** Rod Bearing Clearance Checking Tool. See **Special Tools** .
- **J 43690-100** Rod Bearing Clearance Checking Tool - Adapter Kit. See **Special Tools** .

- **J 45059** Angle Meter

PISTON AND CONNECTING ROD ASSEMBLY PROCEDURE

1. Rotate the crankshaft using the **J 39946** in order to align the crankshaft connecting rod journal being serviced to BDC. See **Special Tools** .
2. Liberally lubricate the cylinder walls, piston rings and piston skirts with clean engine oil.

IMPORTANT: Connecting rod bearings that have been used in a running engine, must be replaced with NEW connecting rod bearings for reassembly.

3. Select the correctly numbered piston/connecting rod assembly for the cylinder. An arrow showing proper piston orientation is located on the top of the piston.

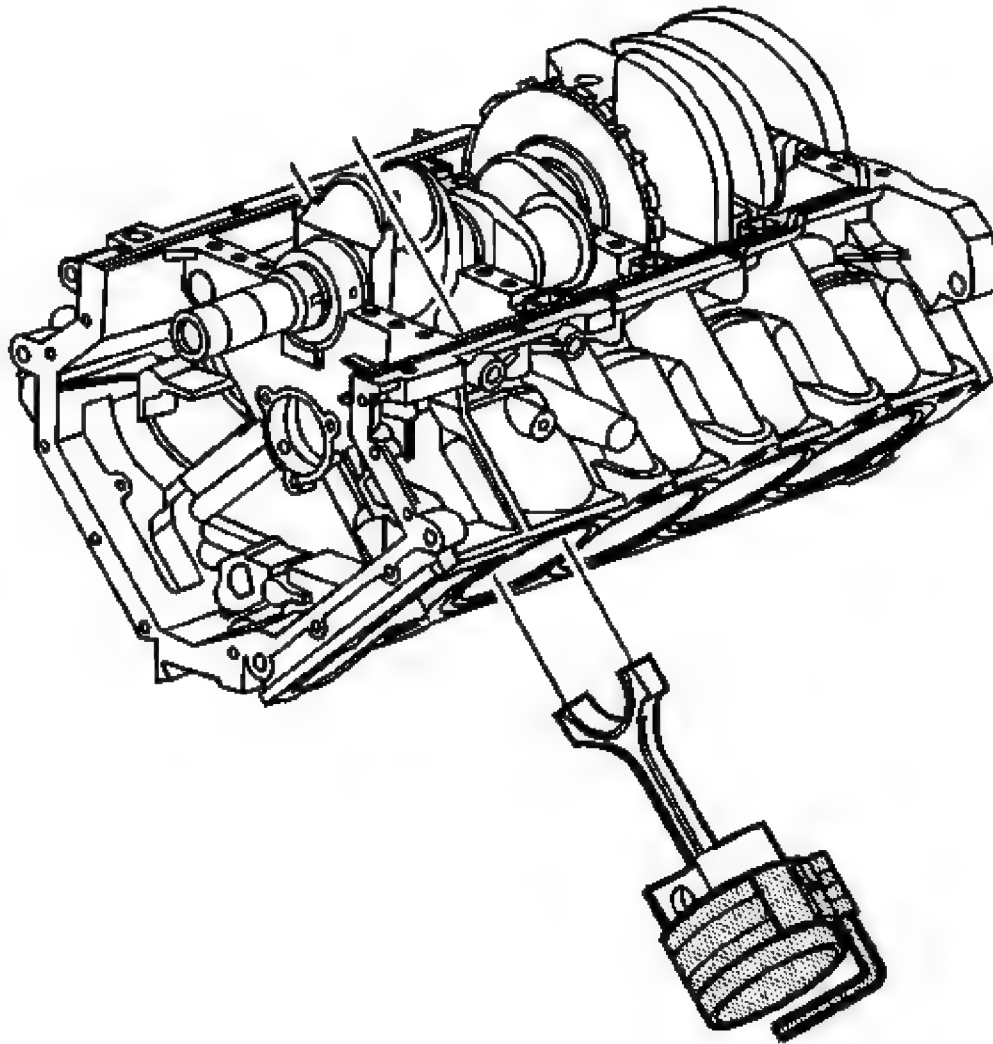


Fig. 282: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

4. Compress the piston rings using the **EN-47701** or equivalent. See **Special Tools** .

IMPORTANT: Extreme care must be exercised when installing the piston and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore or the crankshaft surfaces.

5. Using both hands, slowly guide the piston and connecting rod assembly into the cylinder from the top and bottom of the cylinder. **DO NOT** allow the connecting rod to contact

the cylinder wall.

6. When the piston ring compressor contacts the deck surface, gently tap the piston into the cylinder using the handle end of a dead-blow hammer. Guide the connecting rod onto the crankshaft bearing journal while taping the piston into the cylinder.

CONNECTING ROD BEARING CLEARANCE MEASUREMENT PROCEDURE - USING PLASTIC GAGING

IMPORTANT: Connecting rod bearings that have been used in a running engine, must be replaced with NEW connecting rod bearings for reassembly.

1. Before final assembly it is important to check the clearance of the new connecting rod bearings.
2. Place a length of fresh, room temperature plastic gaging material all the way across all the connecting rod bearing journal.

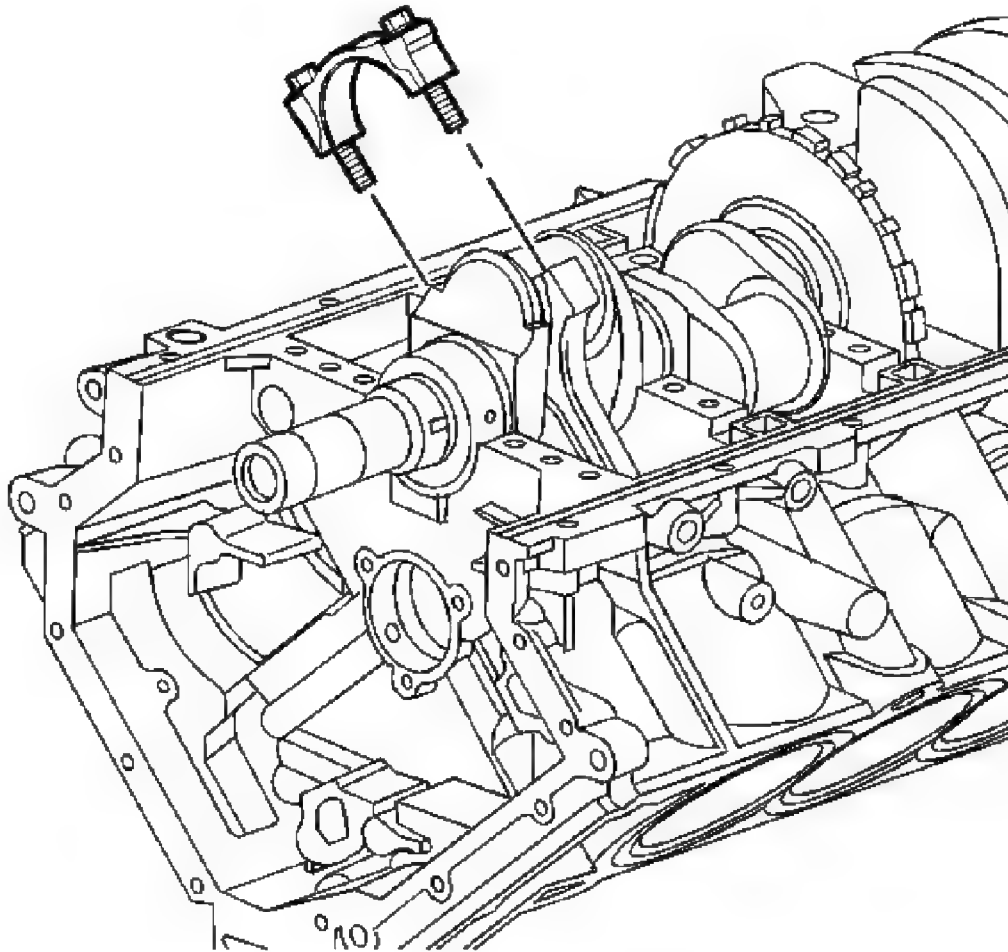


Fig. 283: View Of Rod Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the connecting rod end cap on its original connecting rod making sure the bearing lock tangs are aligned on the same side of the rod.

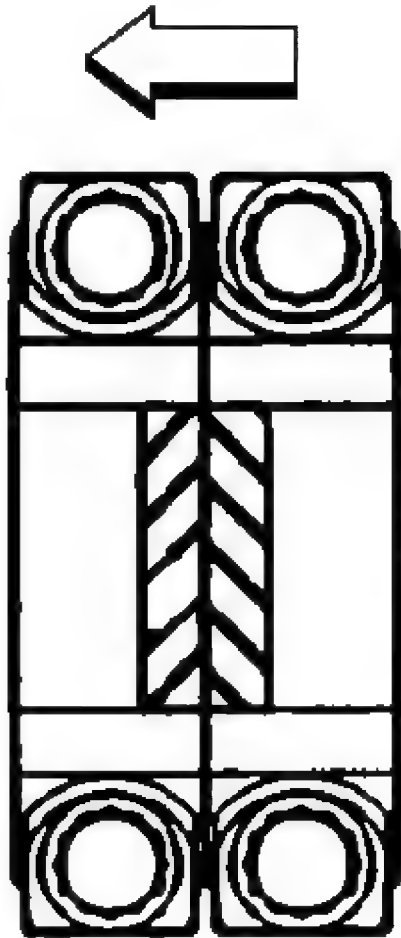


Fig. 284: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

4. When properly installed, the connecting rod bearing cap notches should be paired, as shown, on the crankpin.

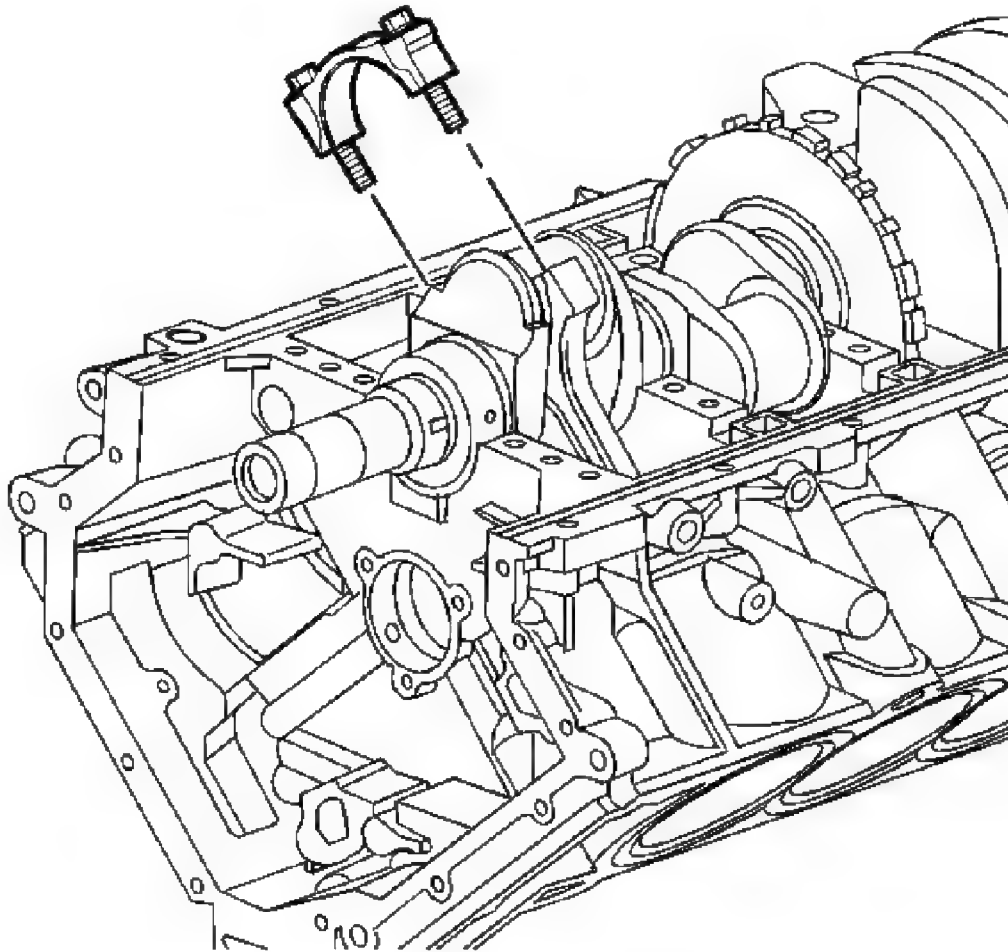


Fig. 285: View Of Rod Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.

5. Lubricate connecting rod bolts with engine oil and install in the connecting rod.

Tighten: Tighten the connecting rod bolts to 30 N.m (22 lb ft).

6. Loosen the connecting rod bolts until the torque reading is zero.
7. Re-tighten the connecting rod bolts.

1. First Pass

Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten: Tighten the connecting rod bolts an additional 110 degrees using the **J 45059**.

8. Allow the assembly to sit for at least 2 minutes.
9. Remove the connecting rod cap bolts.
10. Remove the connecting rod cap.

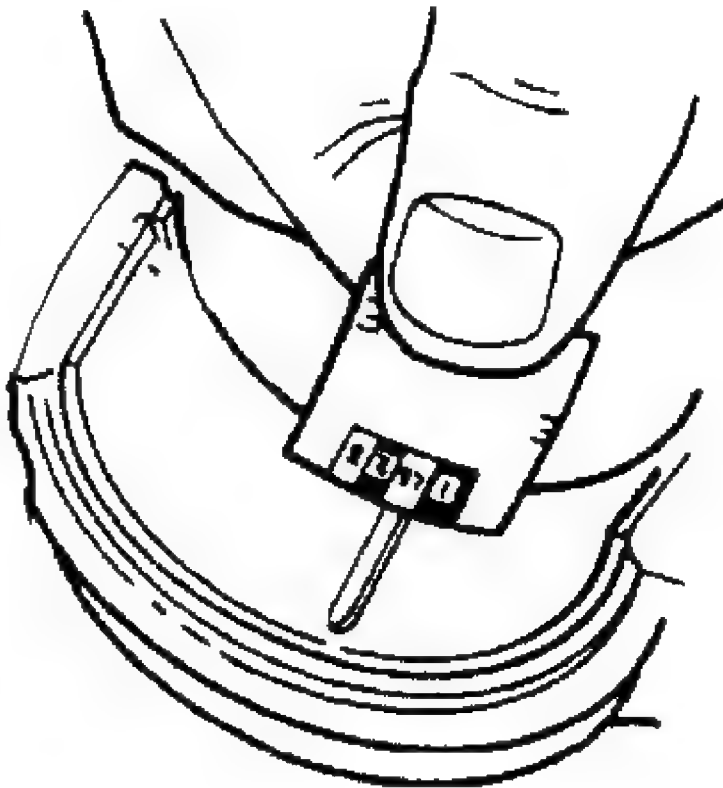


Fig. 286: Measuring Plastigage
Courtesy of GENERAL MOTORS CORP.

11. Determine the connecting rod bearing clearance by comparing the width of the flattened

plastic gaging material at its widest point with the graduation on the gauging material container.

12. Compare the measurements with the engine mechanical specifications. Refer to **Engine Mechanical Specifications** .
13. If the new bearings do not provide the proper crankshaft to bearing clearance, re-measure the crankshaft journals for the correct specified size and check to make sure you have the correct new bearings. If the crankshaft journals are incorrectly sized, replace the crankshaft. No crankshaft machining is permitted and undersized bearings are not available.
14. Clean the plastic gaging material from the connecting rod bearing and crankshaft connecting rod bearing journal using a soft lint-free cloth.

CONNECTING ROD CLEARANCE MEASUREMENT PROCEDURE - USING J 43690 AND J 43690-100

The **J 43690** and the **J 43690-100** have been developed as a more accurate method to measure connecting rod bearing clearances. See **Special Tools** . The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.



- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, -6 Handle (4)
- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)

- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

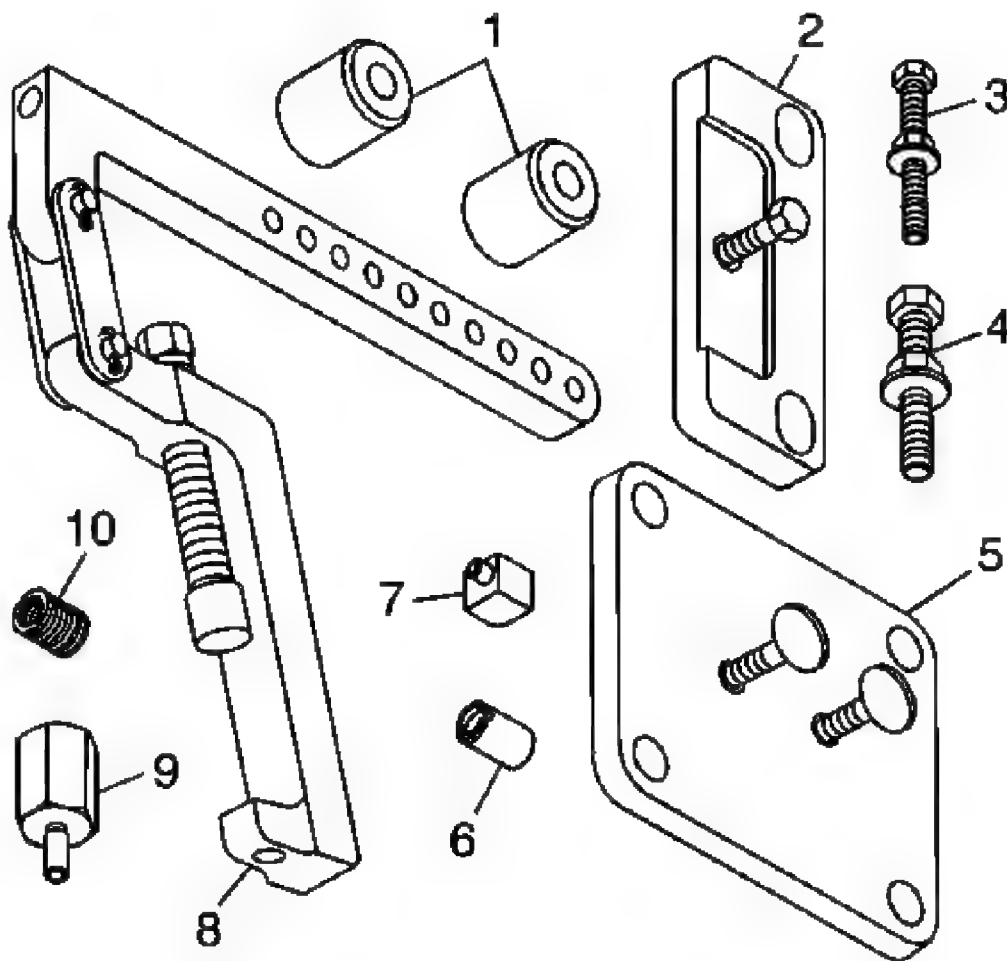


Fig. 288: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of **GENERAL MOTORS CORP.**

J 43690-100 Rod Bearing Clearance Tool - Adapter Kit. See **Special Tools** .

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)

- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

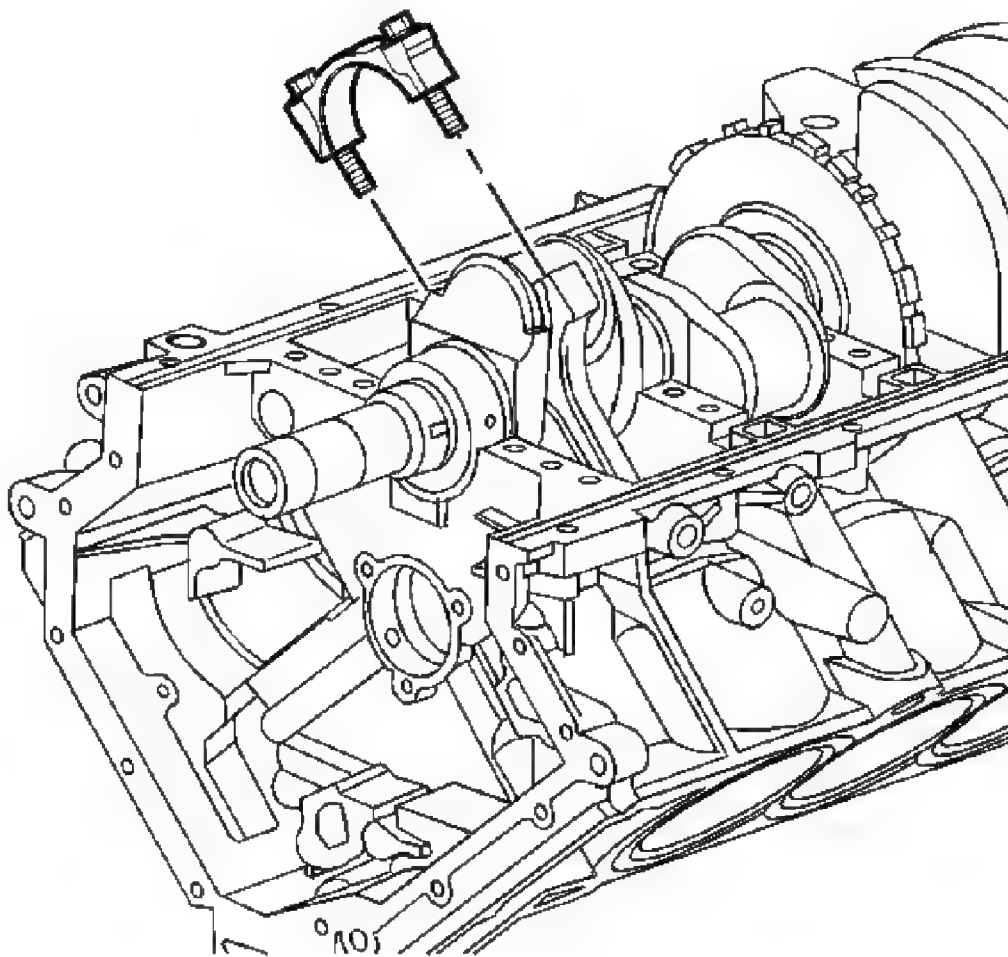


Fig. 289: View Of Rod Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the connecting rod end cap on its original connecting rod making sure the bearing lock tangs are aligned on the same side of the rod.

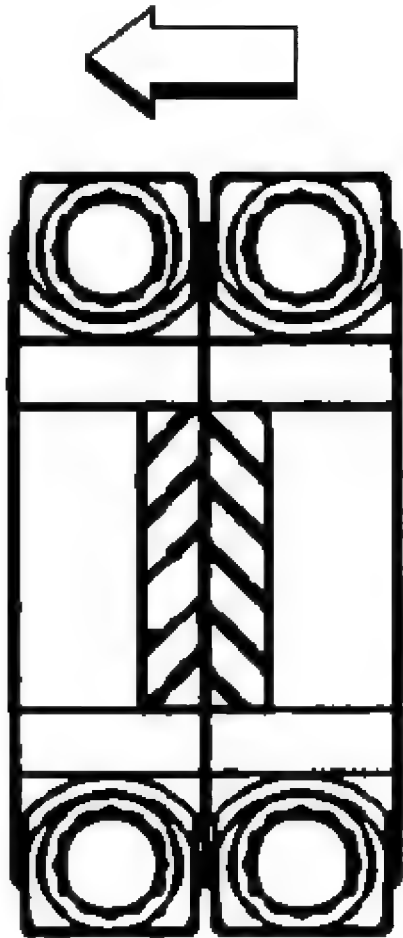


Fig. 290: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

2. When properly installed, the connecting rod bearing cap notches should be paired, as shown, on the crankpin.

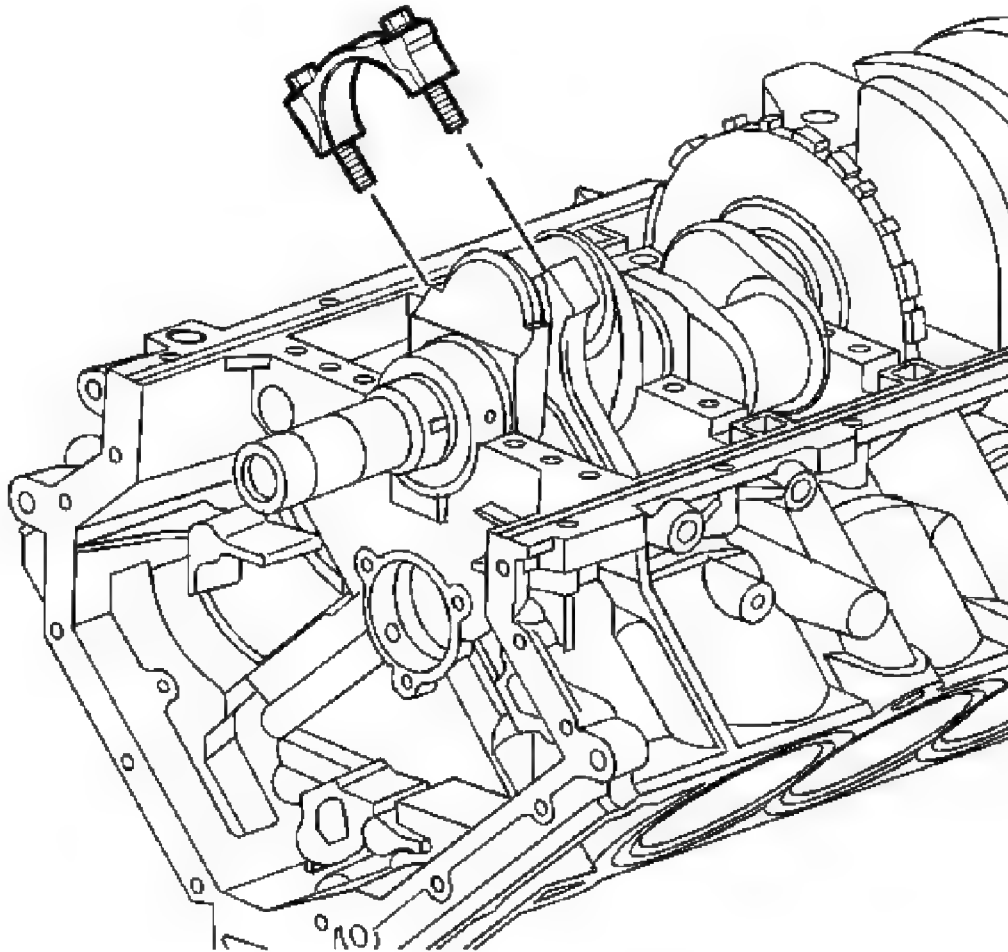


Fig. 291: View Of Rod Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Reuse the old connecting rod bolts ONLY for measuring the connecting rod bearing clearance.

3. Lubricate connecting rod bolts with engine oil and install in the connecting rod.

Tighten: Tighten the connecting rod bolts to 30 N.m (22 lb ft).

4. Loosen the connecting rod bolts until the torque reading is zero.
5. Re-tighten the connecting rod bolts.

1. First Pass

Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten: Tighten the connecting rod bolts an additional 110 degrees using the **J 45059** .

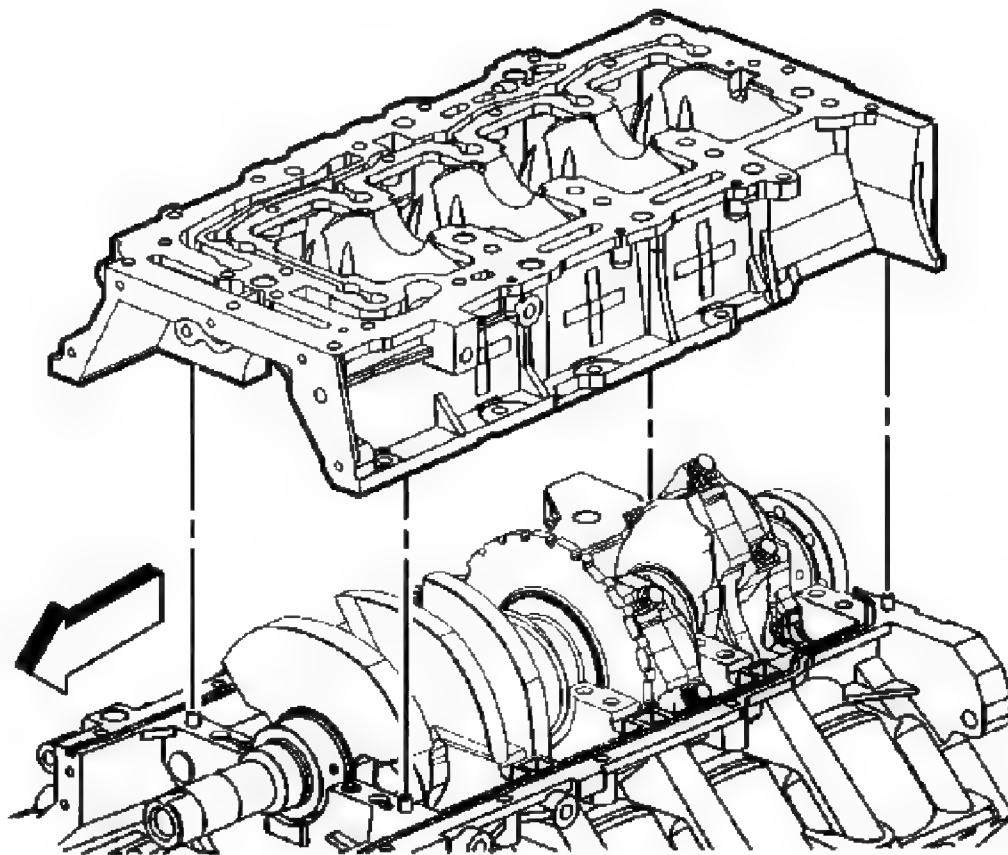


Fig. 292: View Of lower Crankcase
Courtesy of GENERAL MOTORS CORP.

6. Align the lower crankcase with the dowel pins in the upper crankcase.
7. Install the lower crankcase onto the upper crankcase slowly until feeling a positive stop.
8. Inspect the upper-to-lower crankcase joint in order to make sure the lower crankcase is fully seated on the cylinder block.

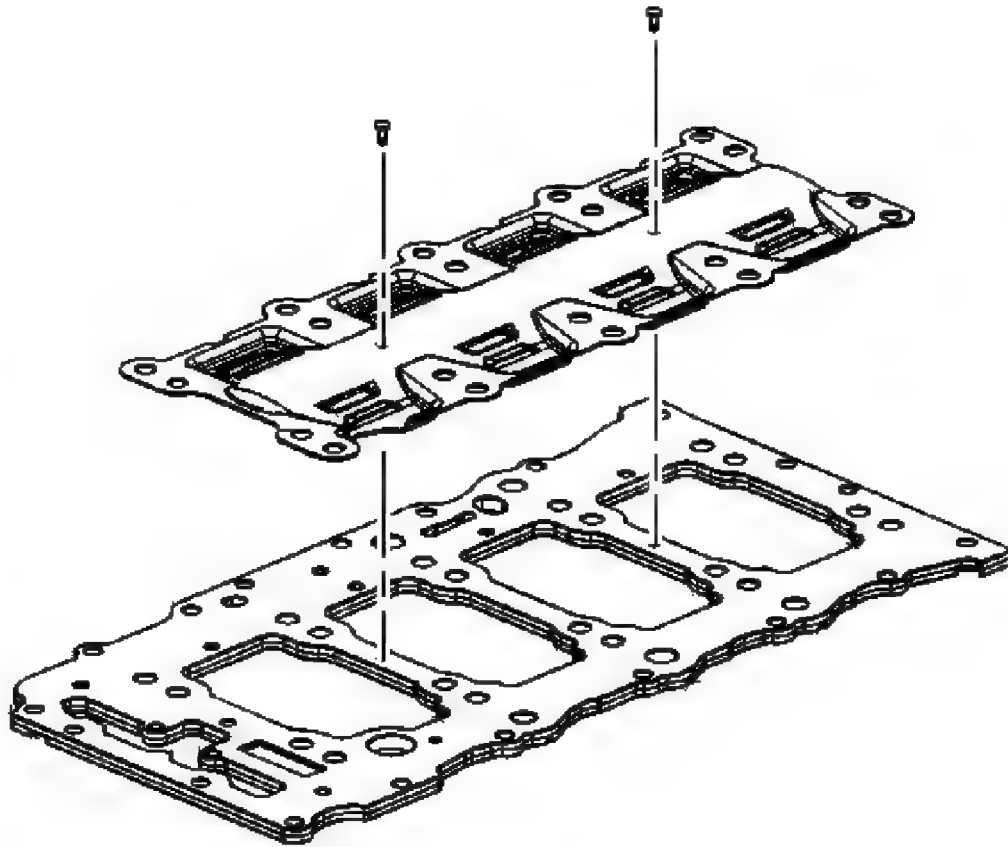


Fig. 293: View Of Oil Scraper Plate & Oil Manifold Plate
Courtesy of GENERAL MOTORS CORP.

9. In order to gain access for the **J 43690** and the **J 43690-100** remove the oil scraper plate from the old oil manifold plate, if fastened into place. See **Special Tools** .

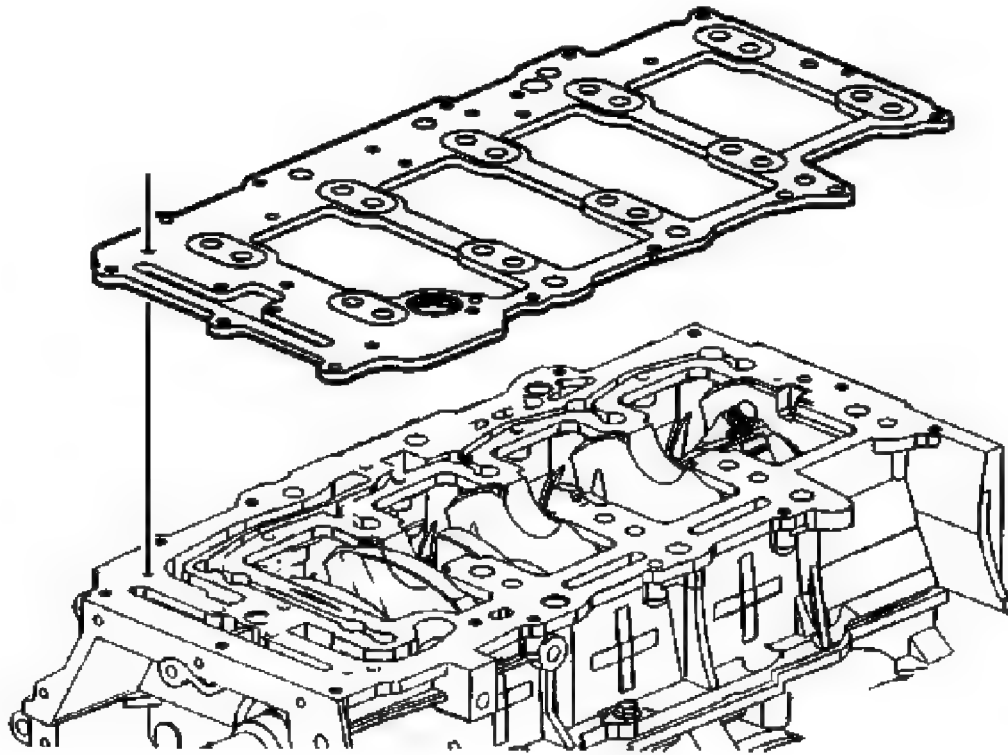


Fig. 294: View of Oil Manifold Plate
Courtesy of GENERAL MOTORS CORP.

10. Install the old oil manifold plate.

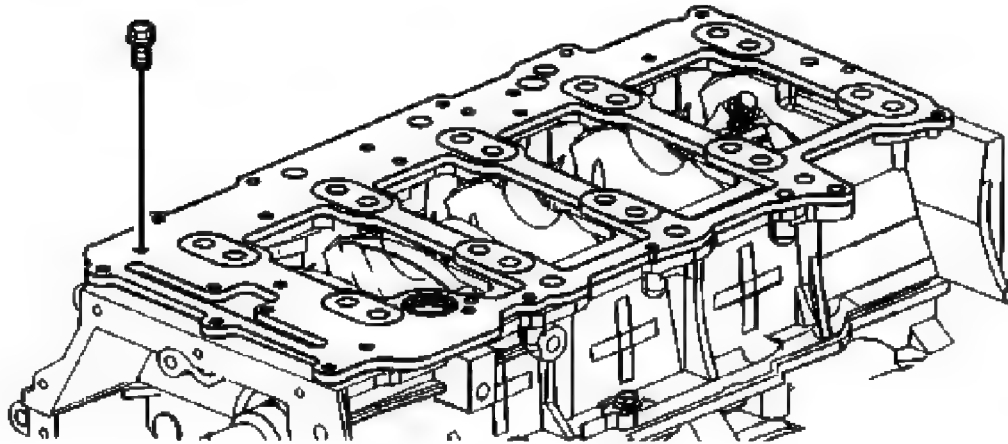


Fig. 295: Identifying Oil Manifold Plate Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the old oil manifold plate bolts.

Tighten: Tighten the old oil manifold plate bolts to 10 N.m (89 lb in).

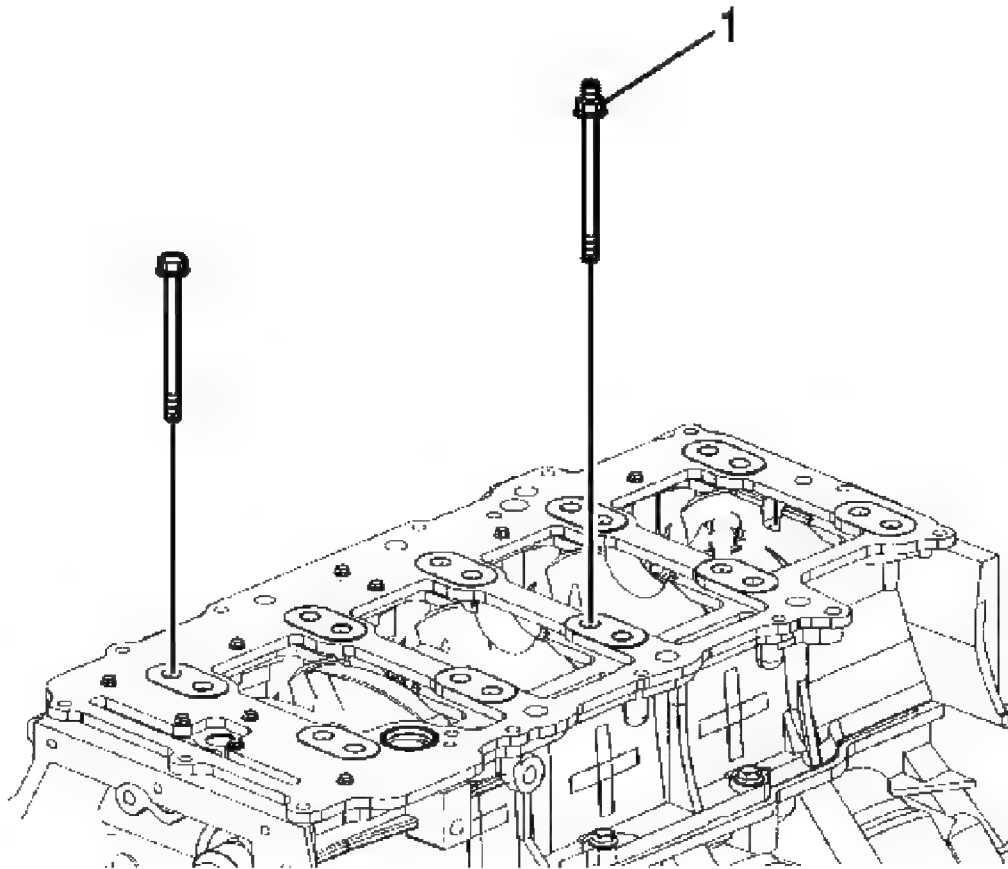


Fig. 296: View Of Lower Crankcase Main Bearing Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the lower crankcase main bearing bolts (1).

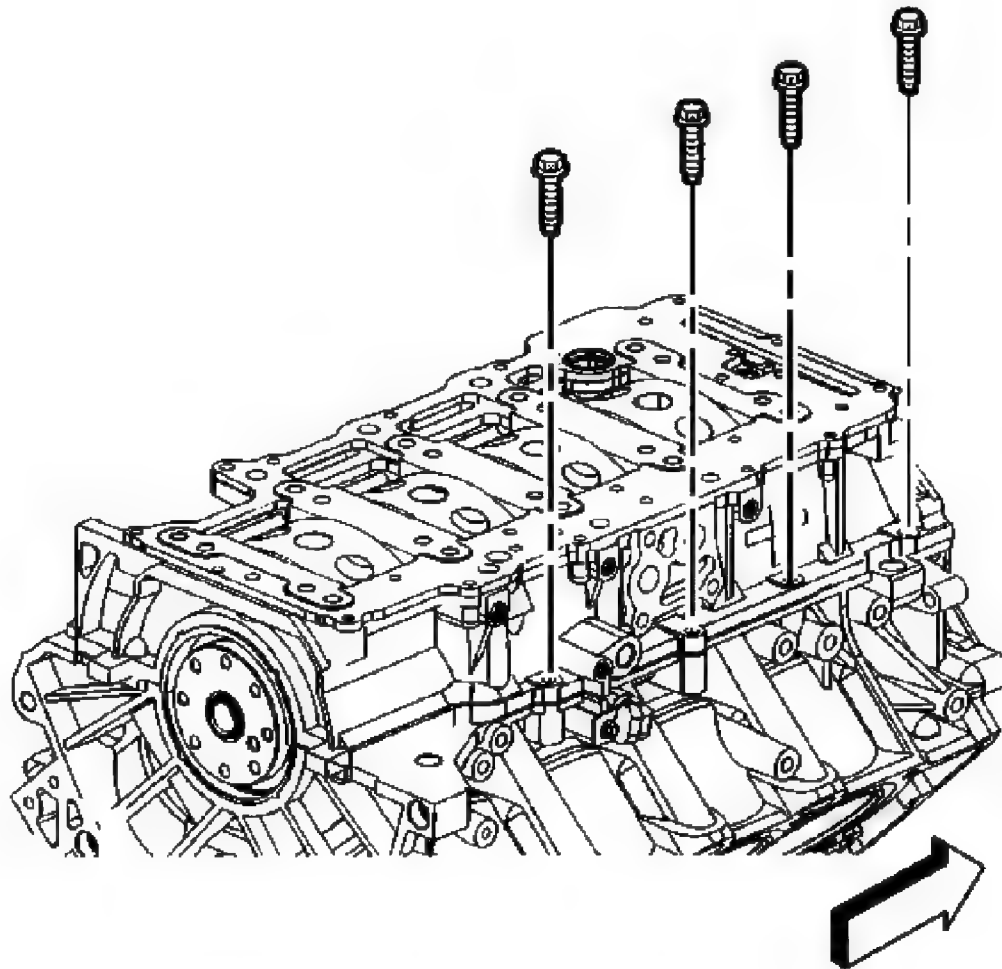


Fig. 297: Identifying Crankcase Perimeter Retaining Bolts On Left Of Engine
Courtesy of GENERAL MOTORS CORP.

13. Install the left side upper-to-lower crankcase perimeter bolts.

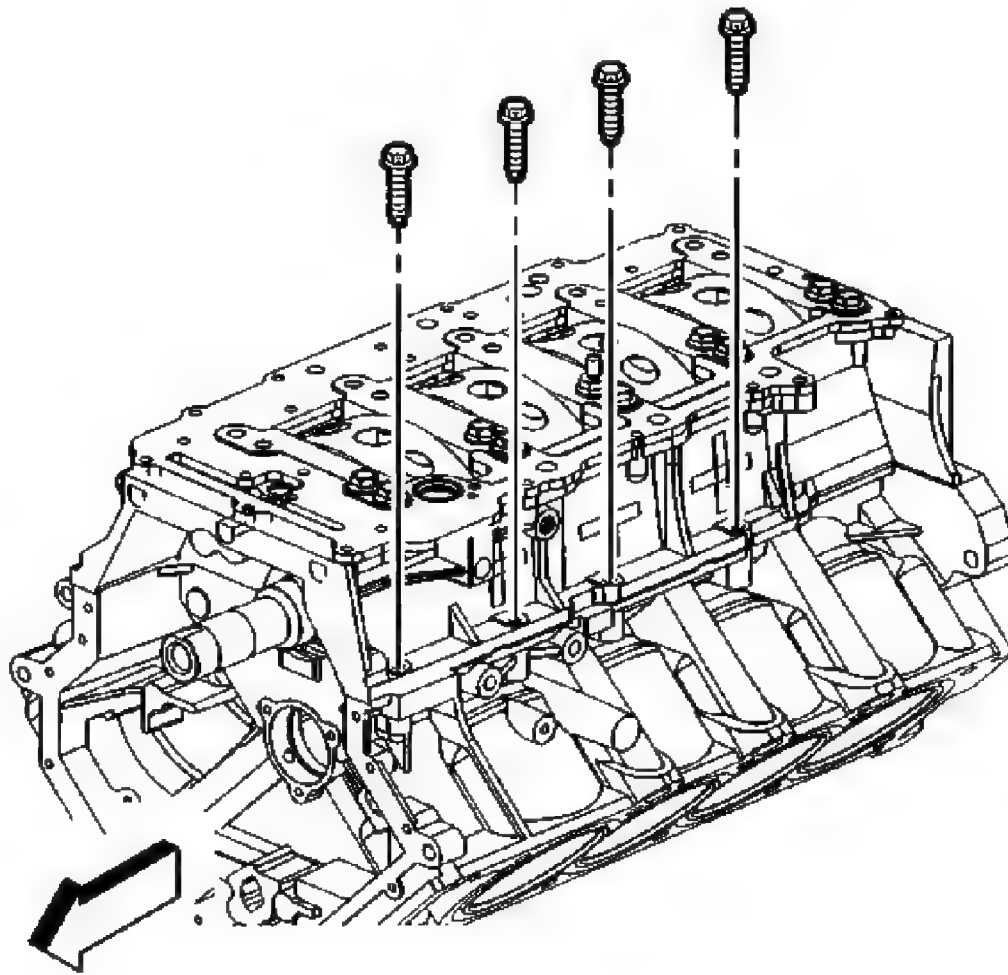


Fig. 298: Identifying Crankcase Perimeter Retaining Bolts On Right Of Engine
Courtesy of GENERAL MOTORS CORP.

14. Install the right side upper-to-lower crankcase perimeter bolts.

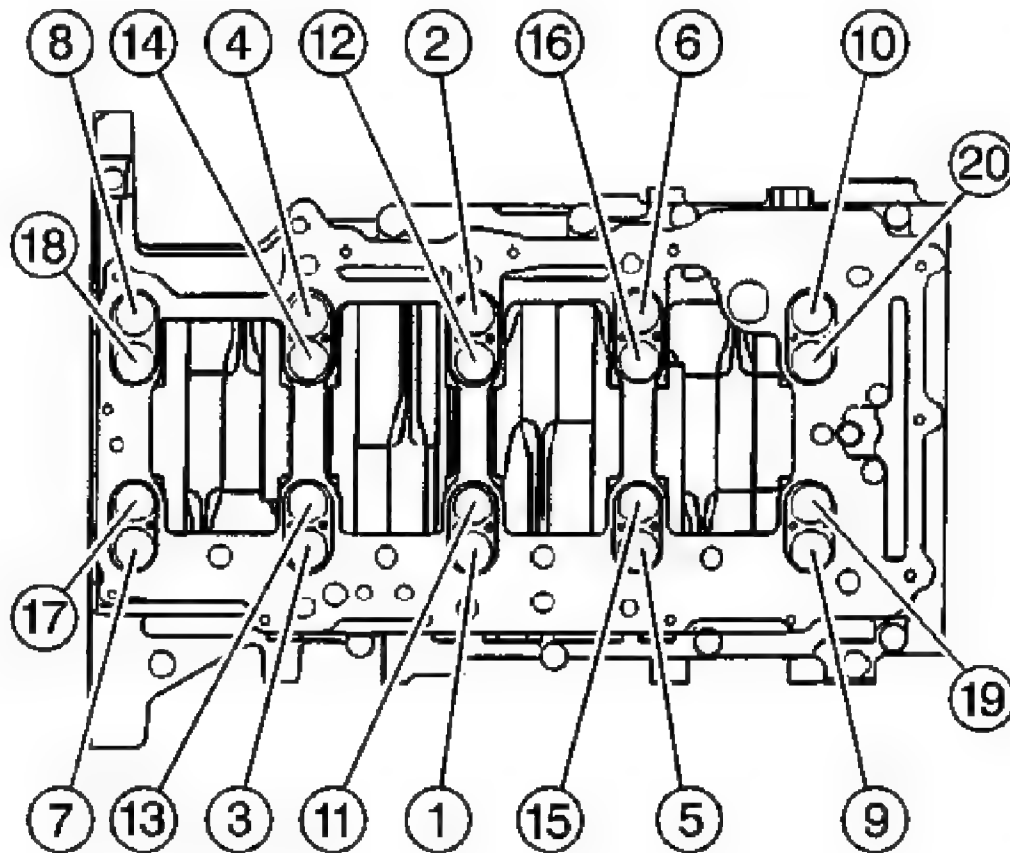


Fig. 299: Identifying Lower Crankcase Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

15. Install the lower crankcase main bearing bolts.

1. First Pass

Tighten: Tighten the lower crankcase main bearing bolts (1-20) to 20 N.m (15 lb ft) in the proper sequence.

2. Final Pass

Tighten: Tighten the lower crankcase main bearing bolts (1-20) an additional 65 degrees in the proper sequence using the **J 45059**.

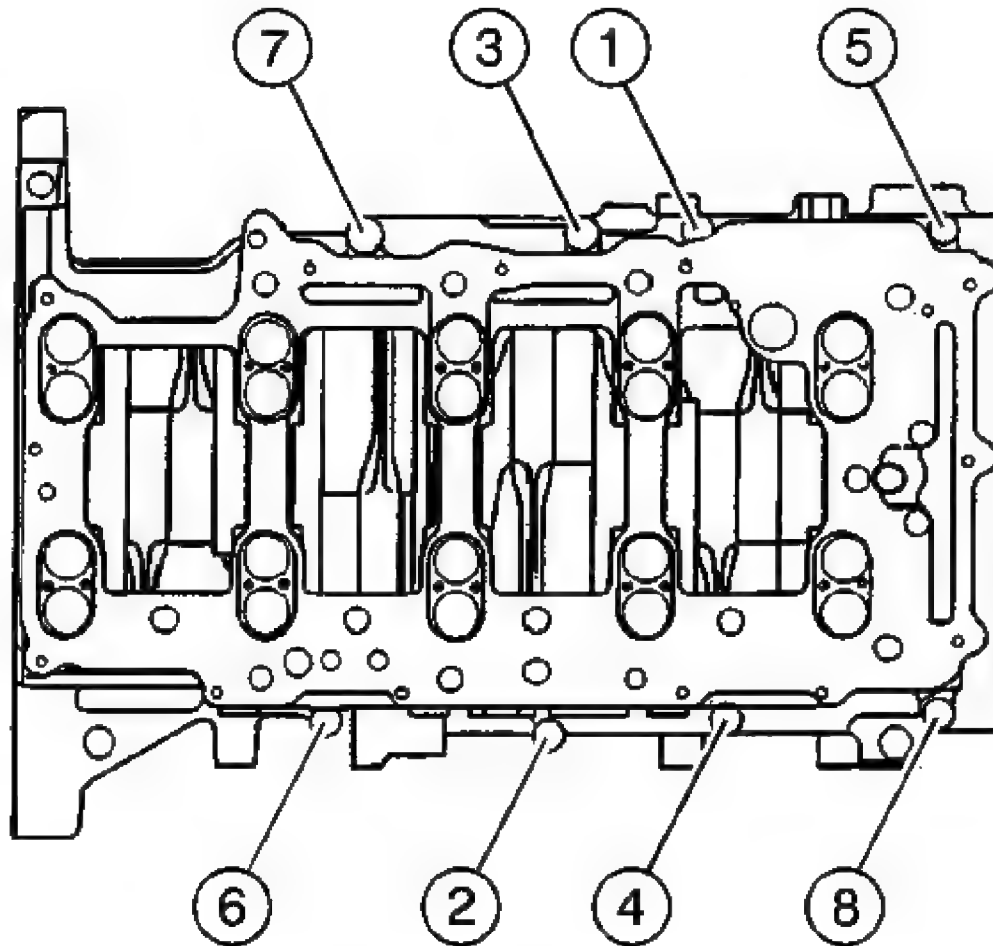


Fig. 300: Tightening Upper-to-lower Crankcase Perimeter Bolts
Courtesy of GENERAL MOTORS CORP.

16. Tighten the upper-to-lower crankcase perimeter bolts (1-8).

Tighten: Tighten the upper-to-lower crankcase perimeter bolts (1-8) to 30 N.m (22 lb ft) in the proper sequence.

17. Rotate the crankshaft until the crankshaft journal and the connecting rod to be measured is in the 12 o'clock position.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

18. Remove the crankshaft main bolts required to install the retainer plate J 43690-105.
19. Install the J 43690-105 retainer plate and crankshaft main bolts. Refer to **Lower Crankcase Installation** for tightening specifications.

IMPORTANT: Do not allow the J 43690-105 retainer plate screw to contact the reluctor ring.

20. Tighten the J 43690-105 retainer plate screw until snug in order to secure the crankshaft movement.
21. Install the foot and bolt to the J 43690-101 pivot arm assembly. Tighten the bolt until snug.
22. Install the J 43690-101 pivot arm assembly onto the connecting rod and tighten the screw securely.
23. Install the base and bolt to the oil pan rail.
24. Align the center of the base with the screw of the J 43690-101 pivot arm assembly. Tighten the bolt until snug.
25. Align the link of the J 43690-101 pivot arm assembly on a plane equal to that of the connecting rod beam.
26. Insert the pin to the base and J 43690-101 pivot arm assembly.
27. Select the adapter as required and install to the swivel base. Tighten until snug.
28. Install the swivel base to the oil pan rail.

IMPORTANT: The clamp of the swivel base and the shaft of the indicator should be free of oil or other debris. A loose or improperly clamped indicator may indicate incorrect readings.

29. Install the indicator to the swivel base. Tighten the clamp of the base until snug.

IMPORTANT: The tip of the indicator should be positioned above and NOT in contact with the end of the connecting rod.

30. Adjust the swivel base as required and position the indicator tip slightly above the connecting rod cap. Lock the swivel base in position by rotating the locking lever.
31. Rotate the fine adjustment knobs on the dial indicator end of the swivel base in order to position the tip of the indicator in contact with the connecting rod.
32. Lightly actuate the handle of the pivot arm assembly, multiple times in both directions, to ensure the oil film is removed from the connecting rod.
33. Load the handle in the forward position and zero the dial indicator. Load the handle multiple times in both directions and record the readings.

34. Refer to **Fastener Tightening Specifications** for proper clearances.
35. Remove the J 43690-105 retainer plate.
36. Install the crankshaft main bolts. Refer to **Lower Crankcase Installation** for tightening specifications.
37. Reposition the tools and repeat Steps 2-21 for all other connecting rods.
38. If clearances do not meet specifications, replace components as required.

CONNECTING ROD FINAL ASSEMBLY PROCEDURE

1. Back the connecting rod away from the crankshaft in order to allow for lubricant application.
2. Coat the crankshaft connecting rod bearing journal and installed connecting rod bearings with GM crankshaft prelube GM P/N 1052367, (Canadian P/N 992869) or equivalent.
3. Guide the connecting rod onto the crankshaft connecting rod bearing journal.

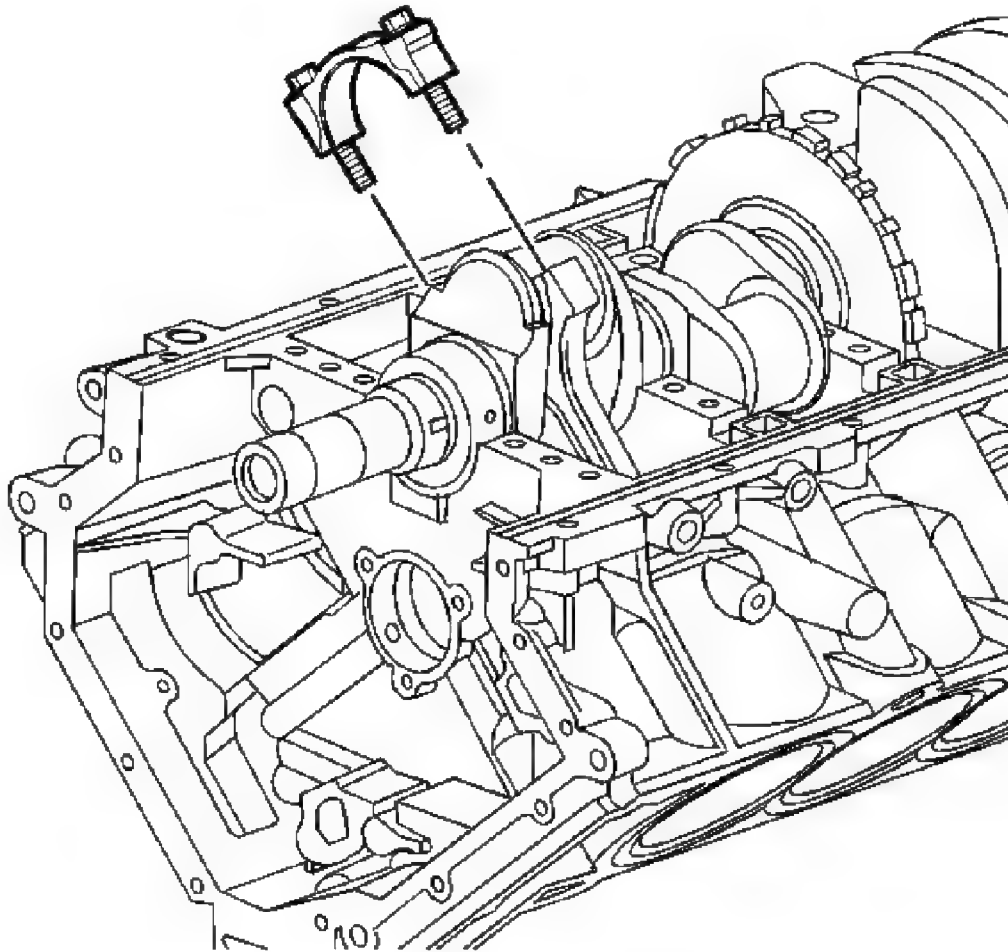


Fig. 301: View Of Rod Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the connecting rod end cap on its original connecting rod making sure the bearing lock tangs are aligned on the same side of the rod.

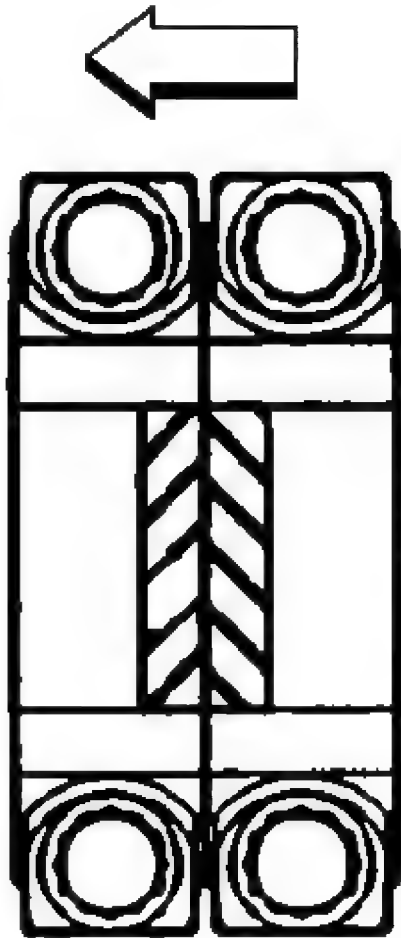


Fig. 302: View Of Paired Connecting Rod Bearing Cap Notches
Courtesy of GENERAL MOTORS CORP.

5. When properly installed, the connecting rod bearing cap notches should be paired, as shown, on the crankpin.

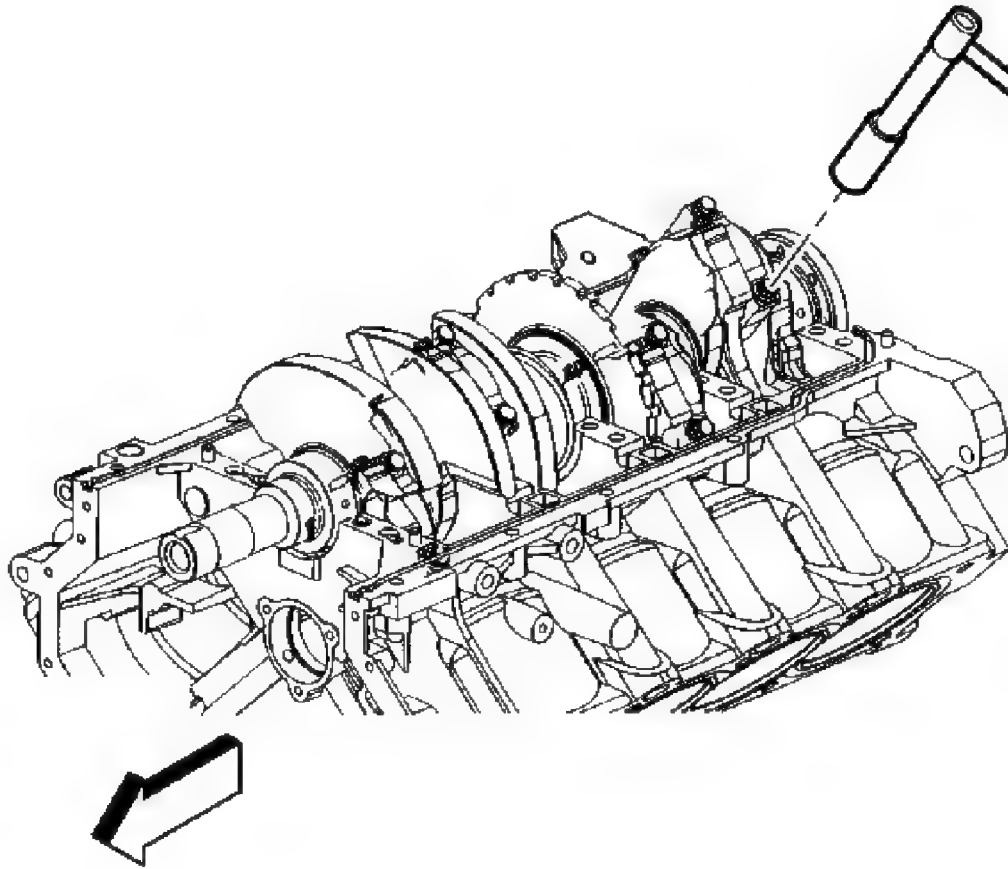


Fig. 303: View Of Connecting Rod & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: DO NOT reuse the old connecting rod bolts.

6. Lubricate the NEW connecting rod bolts with engine oil and install in the connecting rod.

Tighten: Tighten the NEW connecting rod bolts to 30 N.m (22 lb ft).

7. Loosen the connecting rod bolts until the torque reading is zero.
8. Re-tighten the connecting rod bolts.
 1. First Pass

Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft).

2. Final Pass

Tighten: Tighten the connecting rod bolts an additional 110 degrees using the **J 45059** .

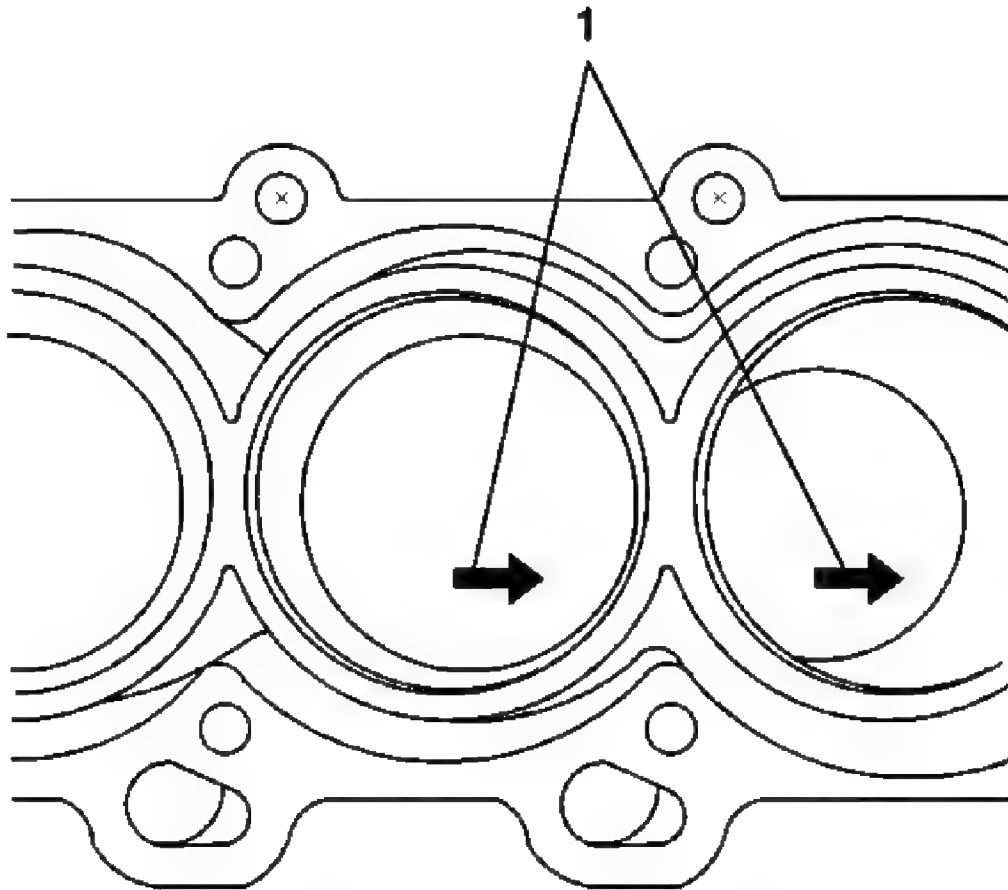


Fig. 304: View Of Locating Arrow On Top Of Pistons
Courtesy of GENERAL MOTORS CORP.

9. During and after installation, check to make sure each piston is positioned properly in the correct cylinder. The locating arrow on the top each piston (1) must be pointing toward the front of the engine.
10. Repeat these procedures for the piston/connecting rod assembly that is using the common crankshaft connecting rod journal.
11. Measure the connecting rod side clearance between the two connecting rods that share

the common crankshaft connecting rod journal.

12. Compare the measurements with the engine mechanical specifications. Refer to **Engine Mechanical Specifications** .
13. If the connecting rods do not provide the proper crankshaft side clearance inspect for the following conditions:
 - If the clearance is too tight, ensure the connecting rods are not binding and can slide parallel to the crankpin. Re-measure the connecting rod widths for the correct specified size. If the connecting rods are incorrectly sized, replace the connecting rods.
 - If the clearance is too loose, re-measure the connecting rod widths for the correct specified size. If the connecting rods are incorrectly sized, replace the connecting rods.
14. Repeat these procedures for the remaining piston/connecting rod assemblies using the **J 39946** in order to rotate the crankshaft. See **Special Tools** .

LOWER CRANKCASE INSTALLATION

TOOLS REQUIRED

- **EN 46109** Guide Pins. See **Special Tools** .
- **J 39946** Crankshaft Socket. See **Special Tools** 4.6L
- **J 45059** Angle Meter

INSTALLATION PROCEDURE

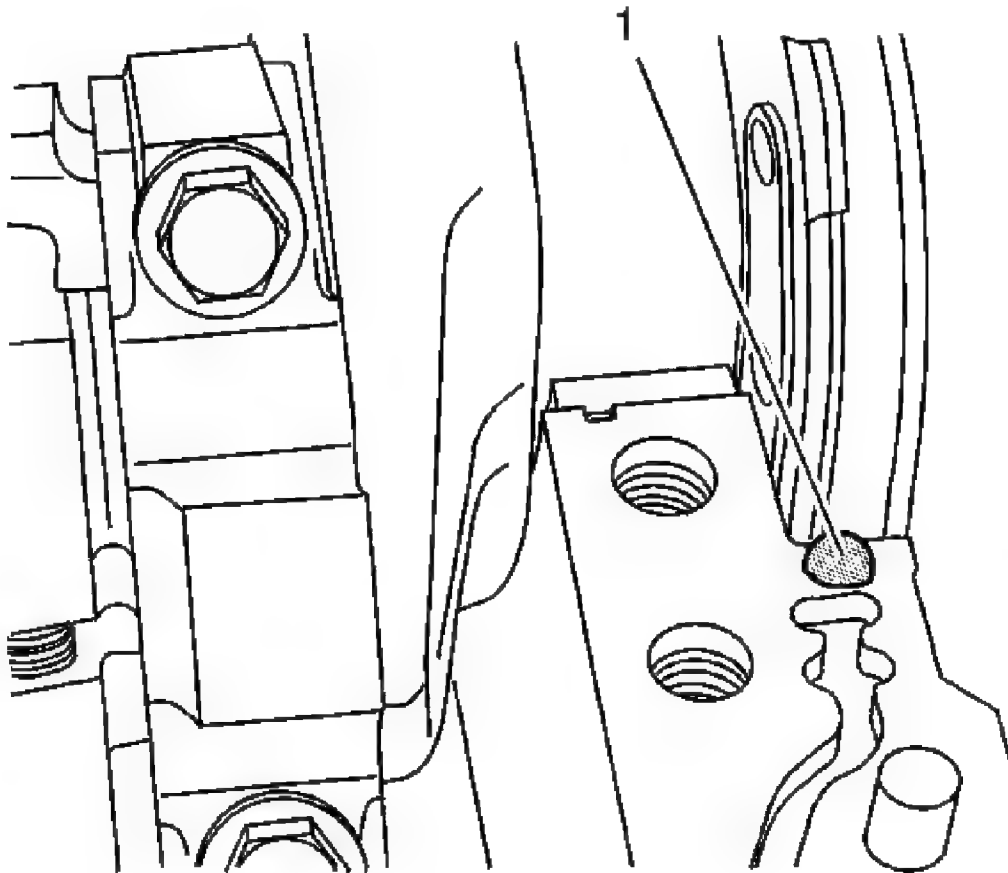


Fig. 305: Identifying RTV Sealant Application Points
Courtesy of GENERAL MOTORS CORP.

1. Place a 5 mm (0.197 in) spot of RTV sealant GM P/N 12378521 or equivalent (1) at the two points where the crankshaft rear oil seal meets the split line of the engine block.

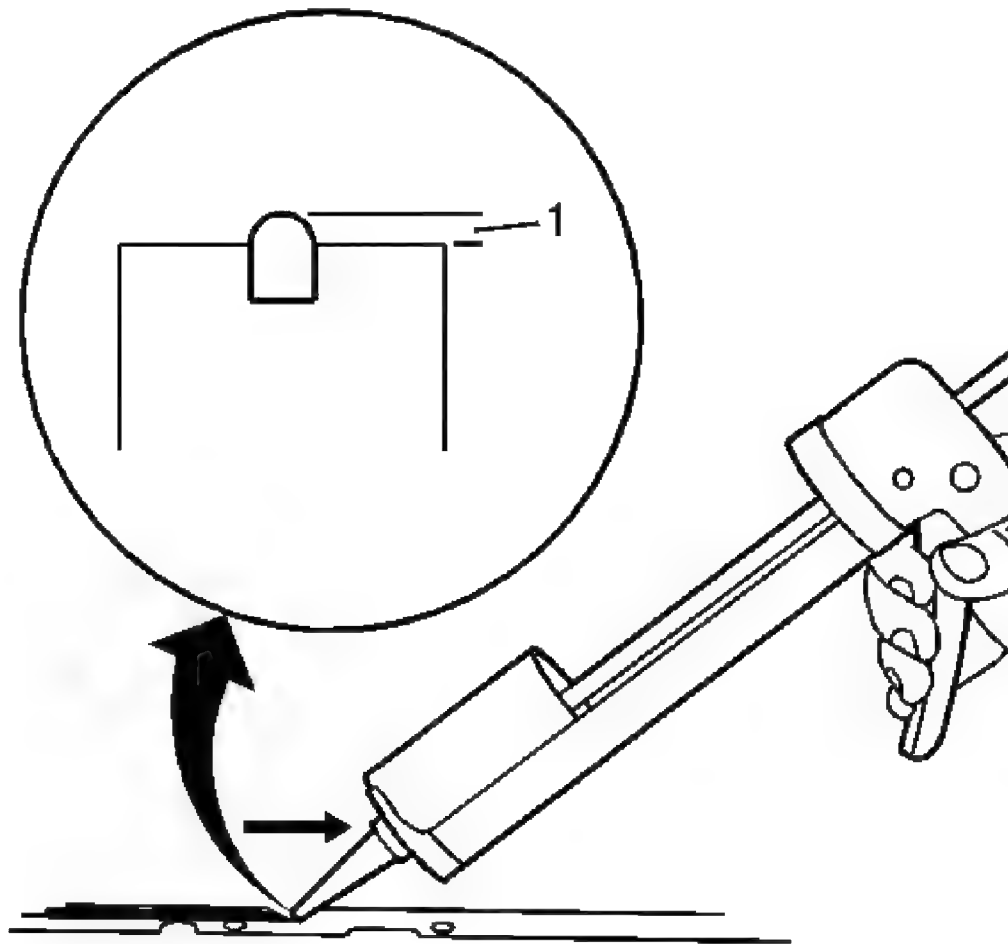


Fig. 306: Applying RTV Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure components being sealed with RTV are assembled within 20 minutes. Components assembled after the RTV has skinned-over, approximately 20 minutes, will not seal properly.

2. Completely fill and slightly overfill the engine block seal groove with a continuous bead of RTV sealant GM P/N 12378521 or equivalent.
3. Ensure the RTV sealant GM P/N 12378521 or equivalent bead is higher than the rail surface (1) by 3 mm (0.118 in).

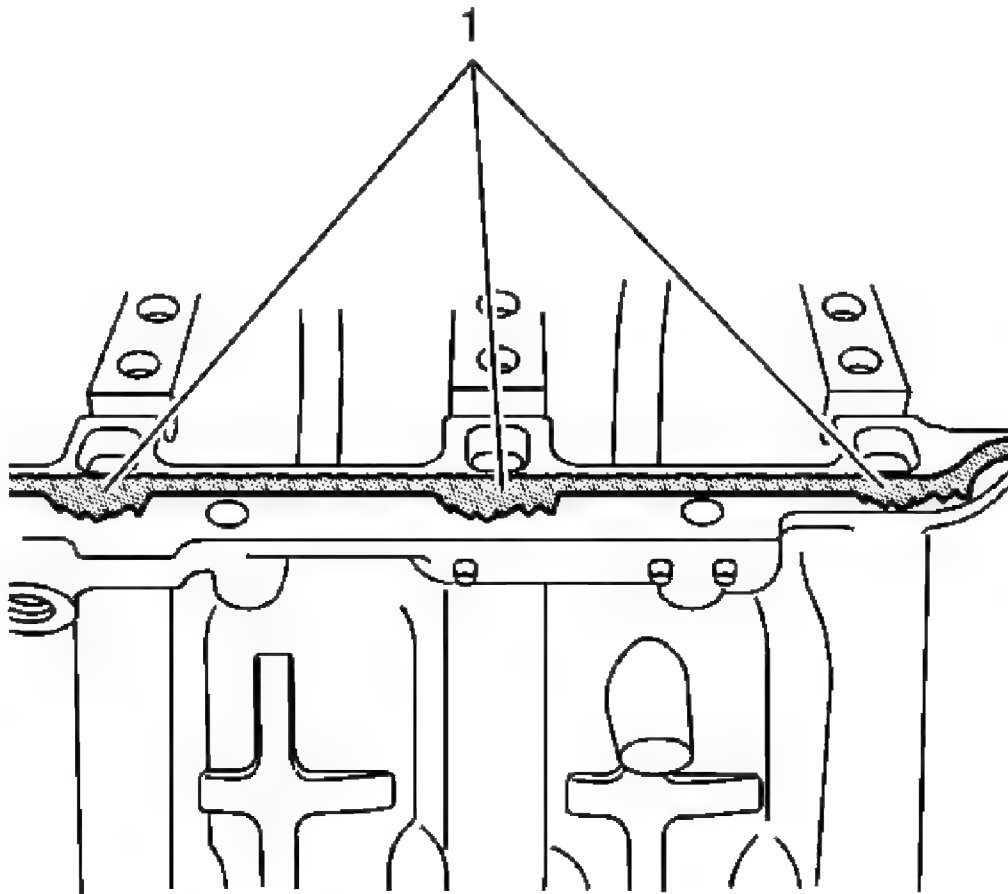


Fig. 307: Spreading RTV Sealant Near The Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

4. Using a suitable tool spread the sealant in the area near the oil drain back passages (1) away from the oil drain back passages toward the outboard edge of the rail surface.

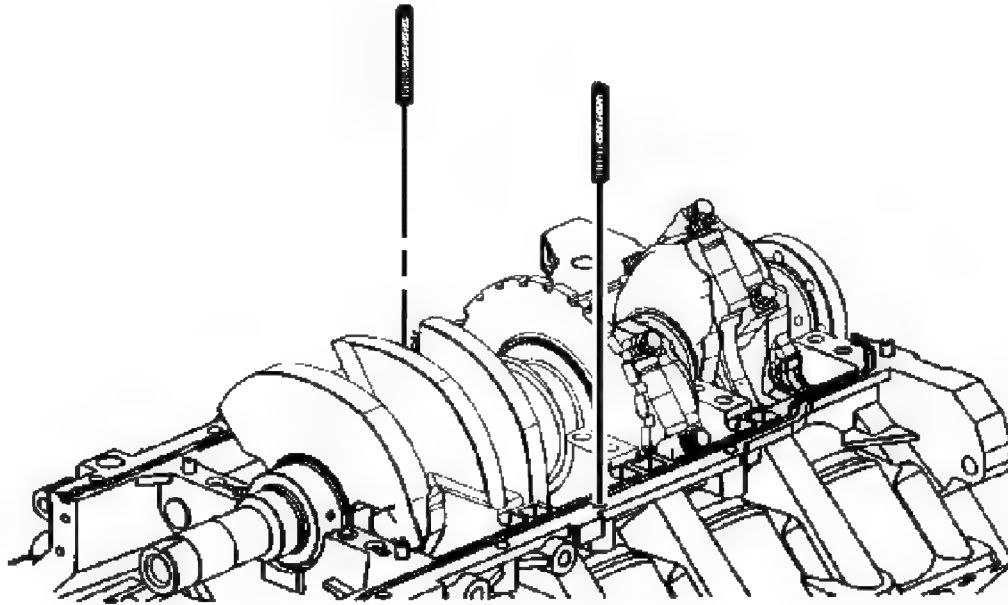


Fig. 308: Identifying EN 46109 Guide Pins
Courtesy of GENERAL MOTORS CORP.

5. To prevent shifting of the lower crankcase install one of the **EN 46109** into a bolt hole in each rail. See **Special Tools** .

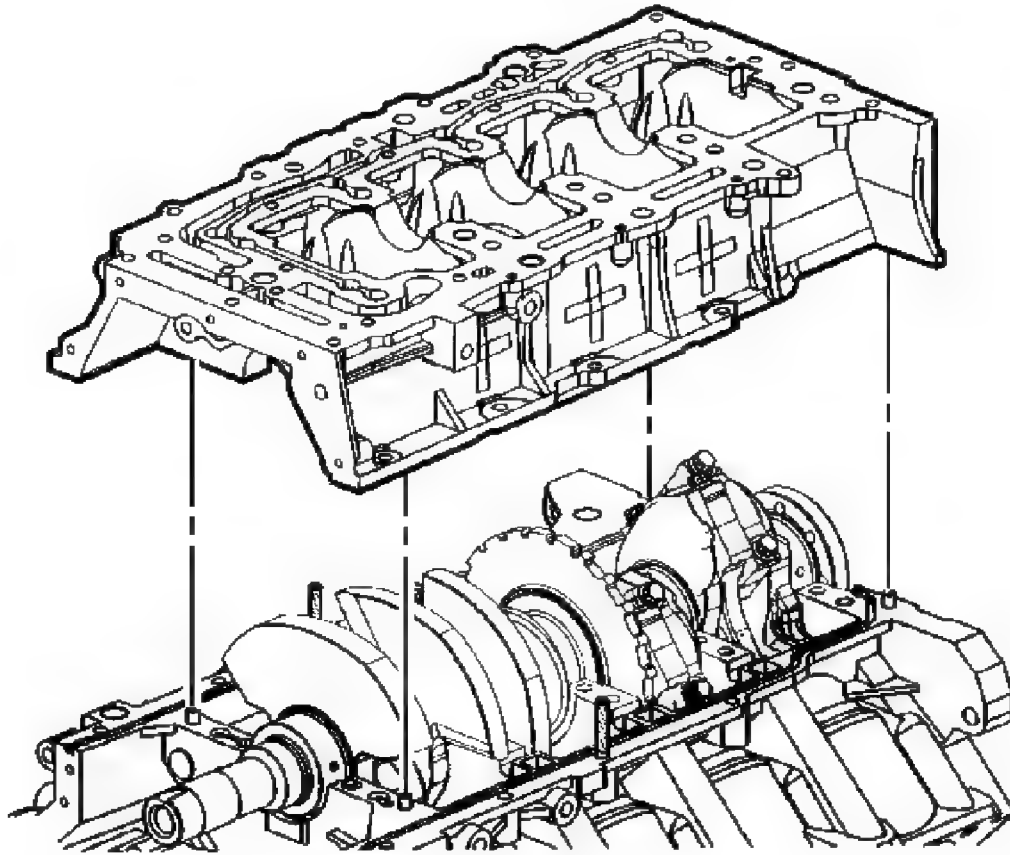


Fig. 309: View Of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

6. Install the cleaned lower crankcase onto the engine.

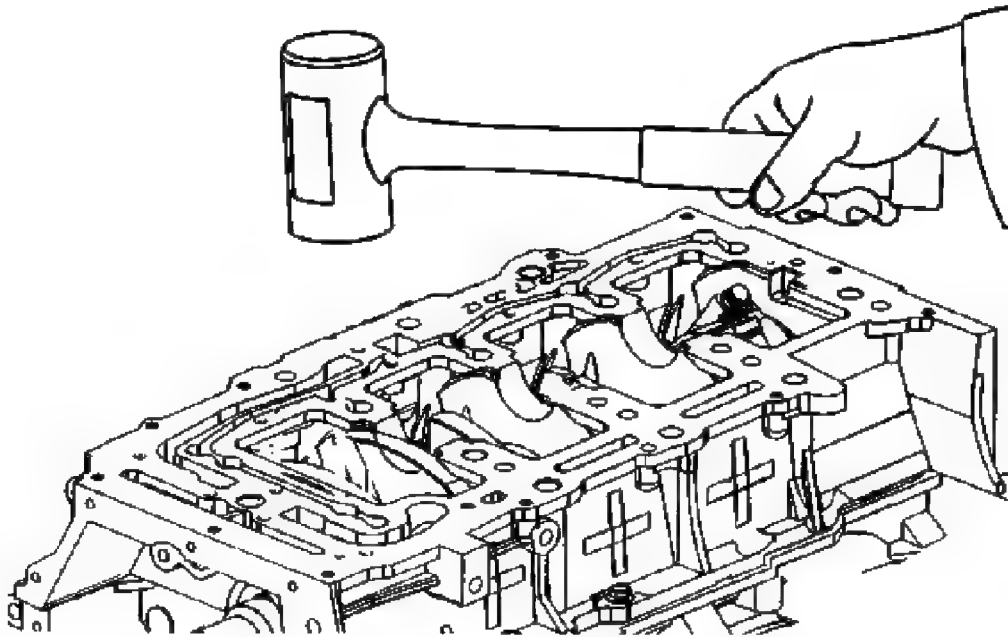


Fig. 310: Tapping Lower Crankcase To Position
Courtesy of GENERAL MOTORS CORP.

7. Using a rubber mallet gently tap the lower crankcase into position.
8. Remove both of the **EN 46109** . See **Special Tools** .

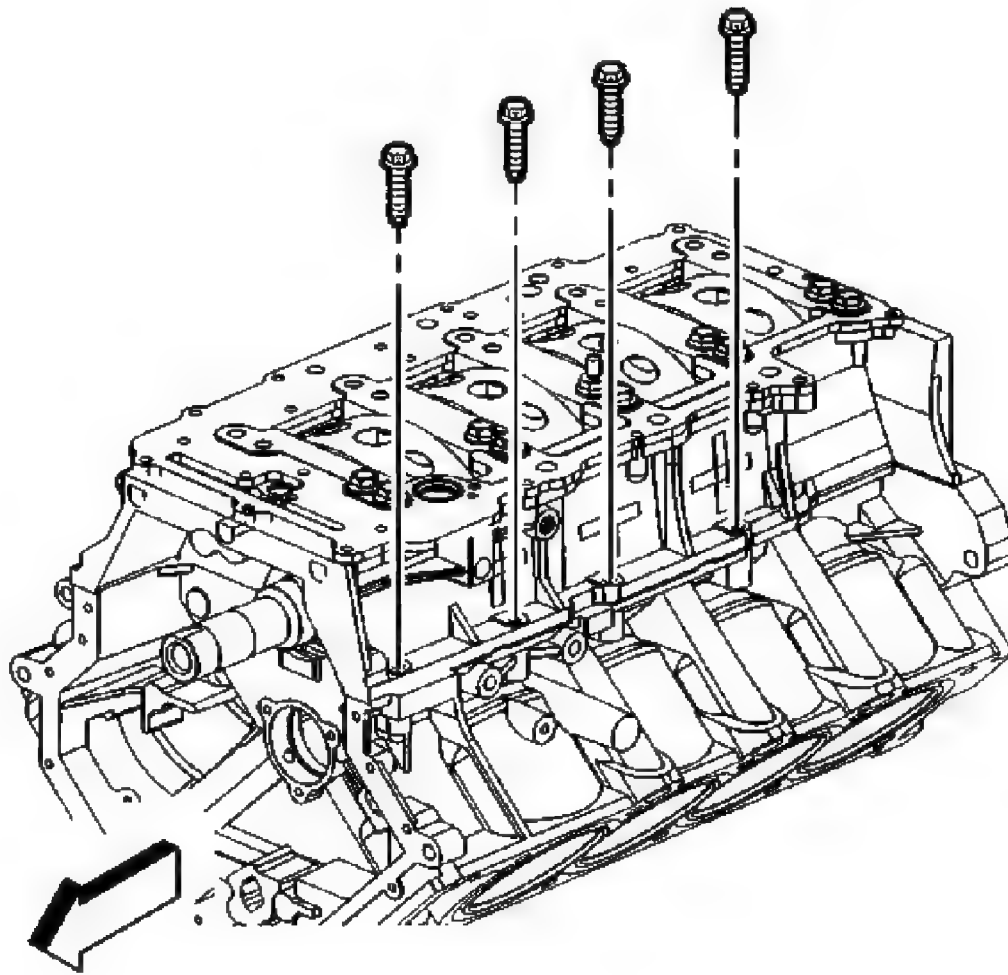


Fig. 311: Identifying Crankcase Perimeter Retaining Bolts On Right Side Of Engine

Courtesy of GENERAL MOTORS CORP.

9. Loosely install the crankcase perimeter bolts on the right side.

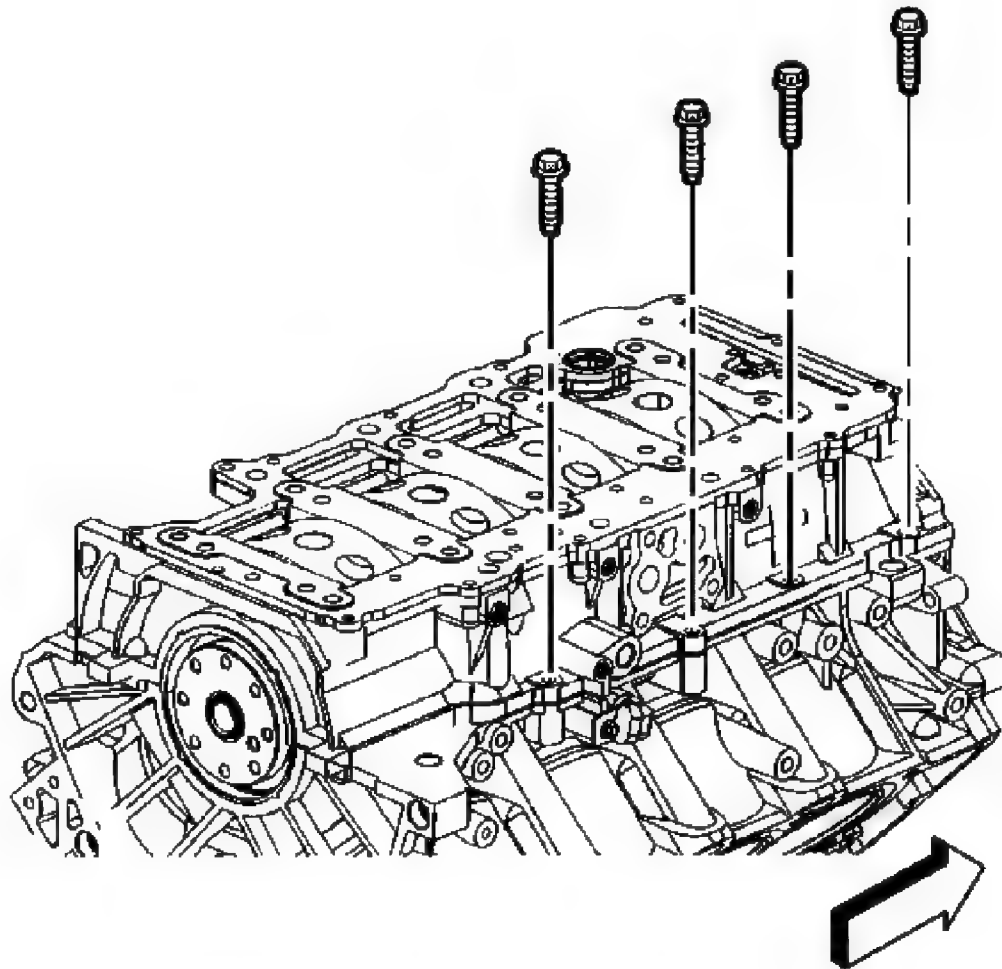


Fig. 312: Identifying Crankcase Perimeter Retaining Bolts On Left Side Of Engine

Courtesy of GENERAL MOTORS CORP.

10. Loosely install the crankcase perimeter bolts on the left side.

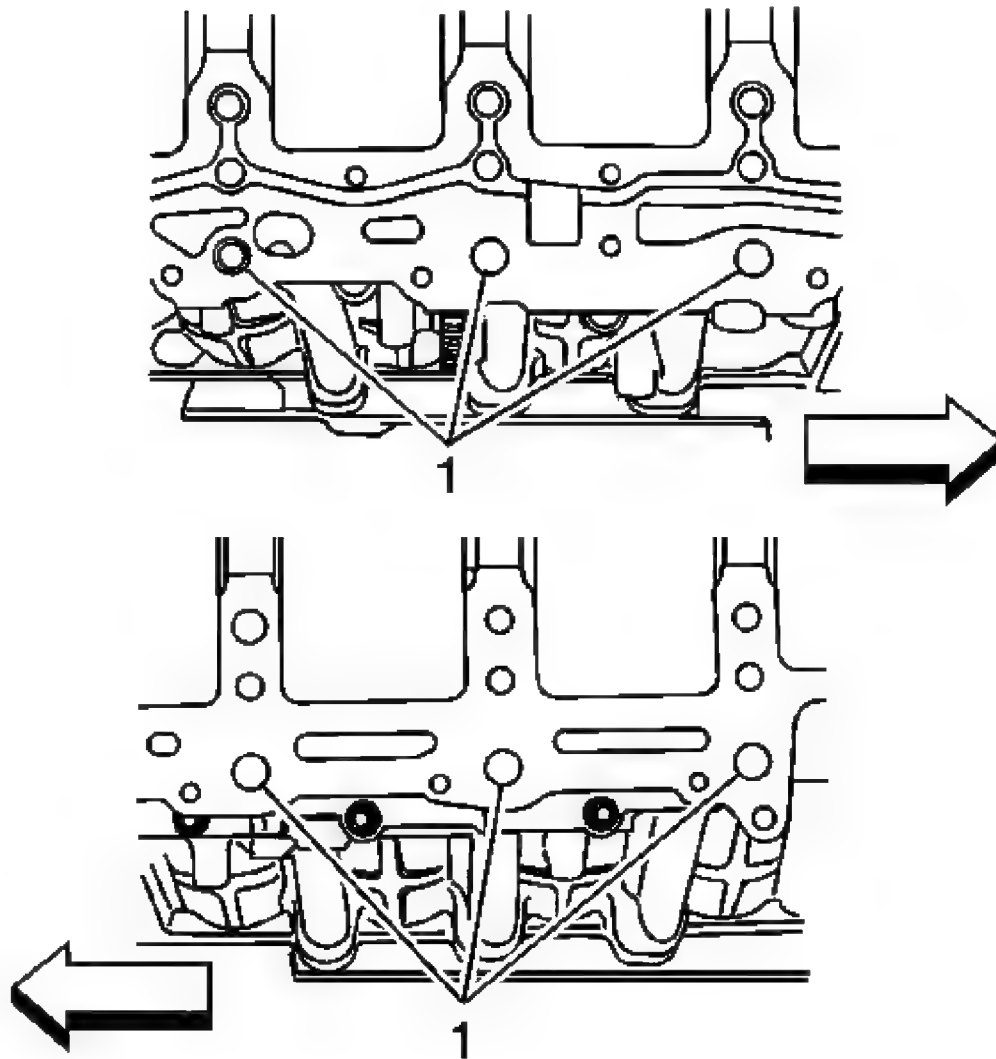


Fig. 313: Locating Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

11. Using a small long blade screwdriver clean out any sealant in the oil drain back passages (1).

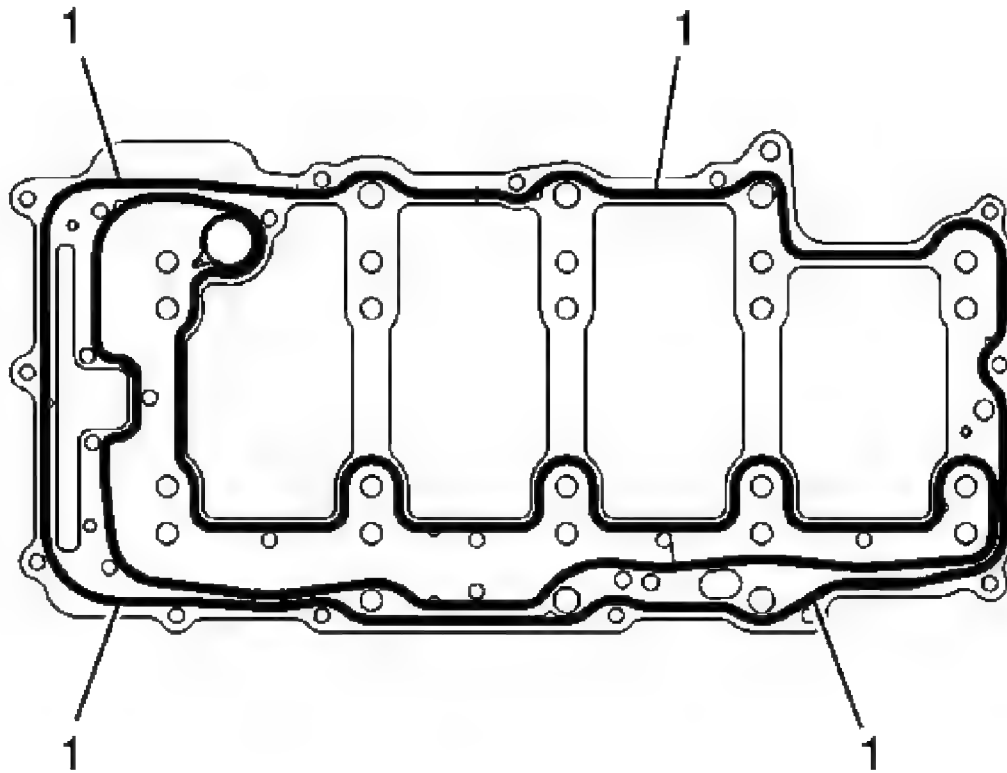


Fig. 314: Identifying RTV Application Areas
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure components being sealed with RTV are assembled within 20 minutes. Components assembled after the RTV has skinned-over, approximately 20 minutes, will not seal properly.

12. Using a NEW oil distribution plate place a continuous 3 mm (0.118 in) wide bead of RTV sealant GM P/N 12378521 or equivalent on top of the outer seal (1) of the oil distribution plate place.

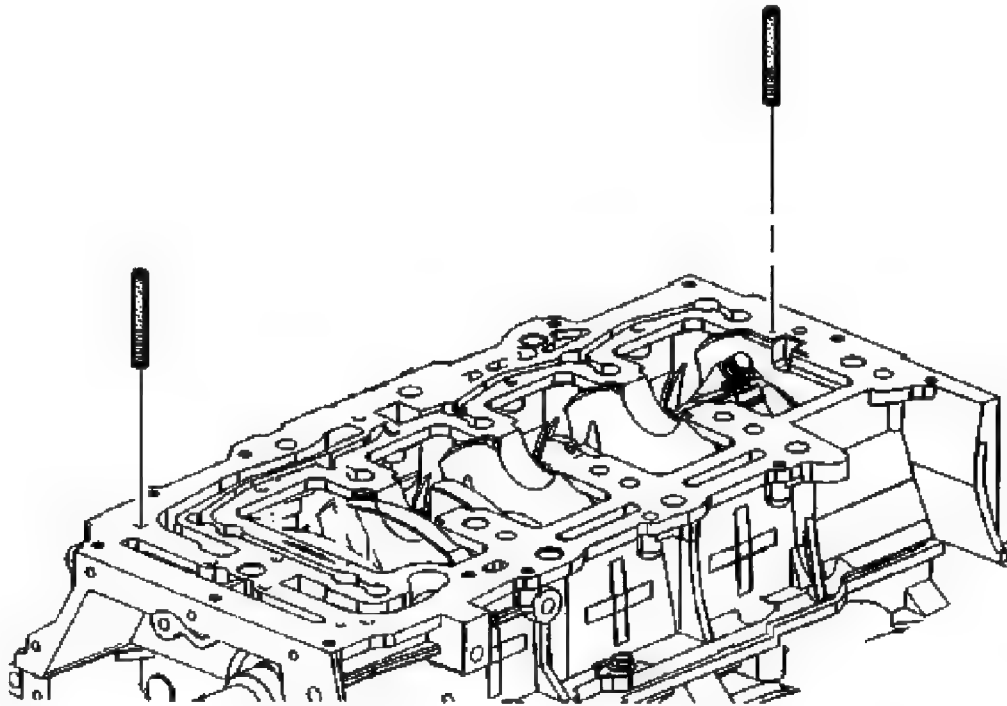


Fig. 315: Identifying Guide Pins
Courtesy of GENERAL MOTORS CORP.

13. To prevent shifting of the oil distribution plate install one of the **EN 46109** into a bolt hole in each side of the lower crankcase. See **Special Tools** .

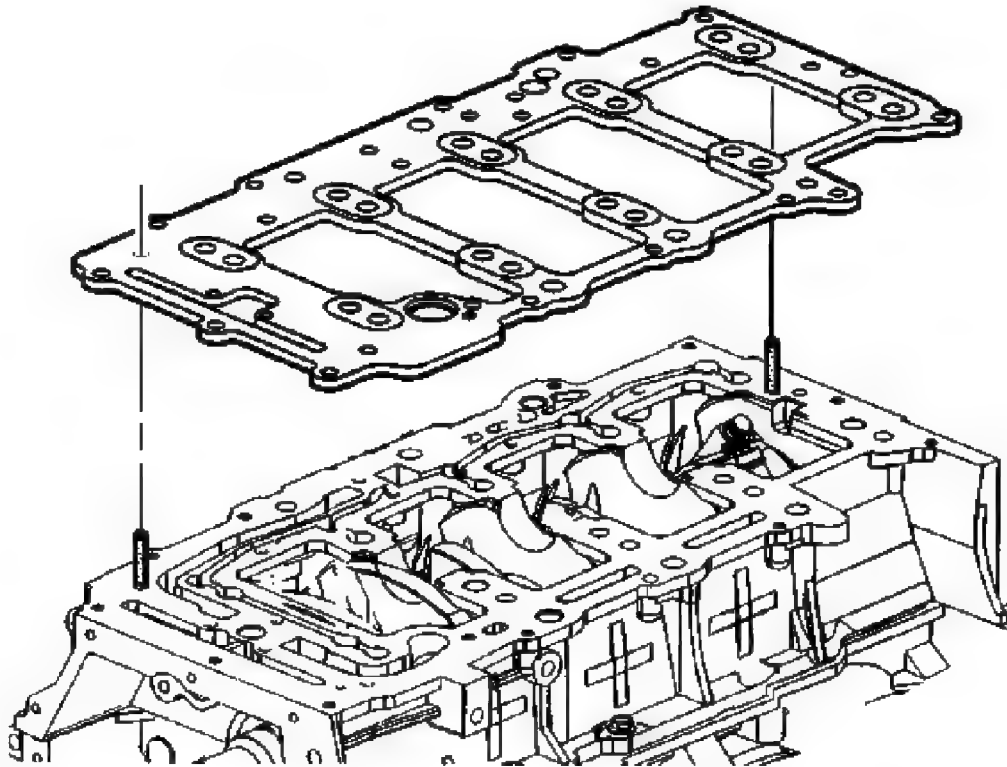


Fig. 316: View Of Oil Distribution Plate
Courtesy of GENERAL MOTORS CORP.

14. Install the NEW oil distribution plate.
15. Remove both of the **EN 46109** . See **Special Tools** .

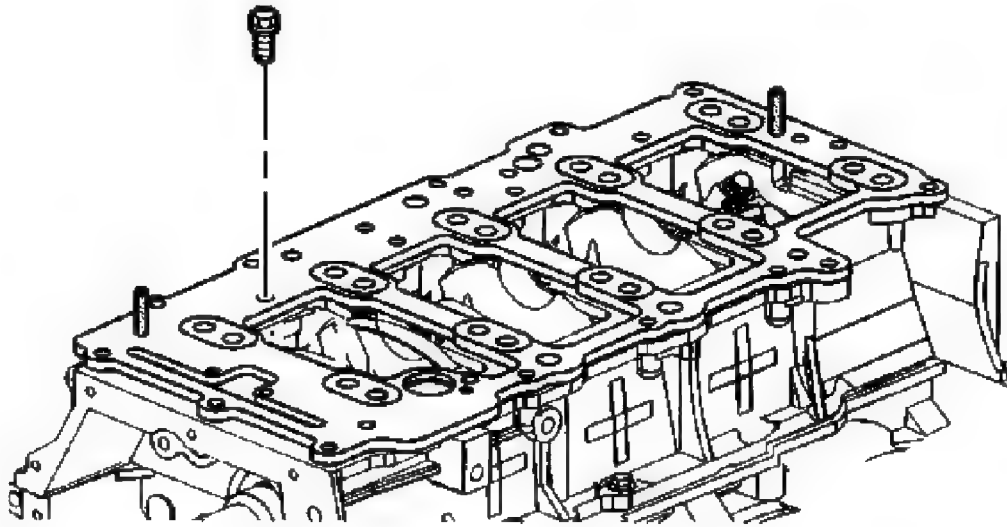


Fig. 317: Identifying Oil Distribution Plate Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to SPECIAL FASTENER NOTICE .

16. Install the oil distribution plate bolts.

Tighten: Tighten the oil distribution plate bolts to 10 N.m (89 lb in).

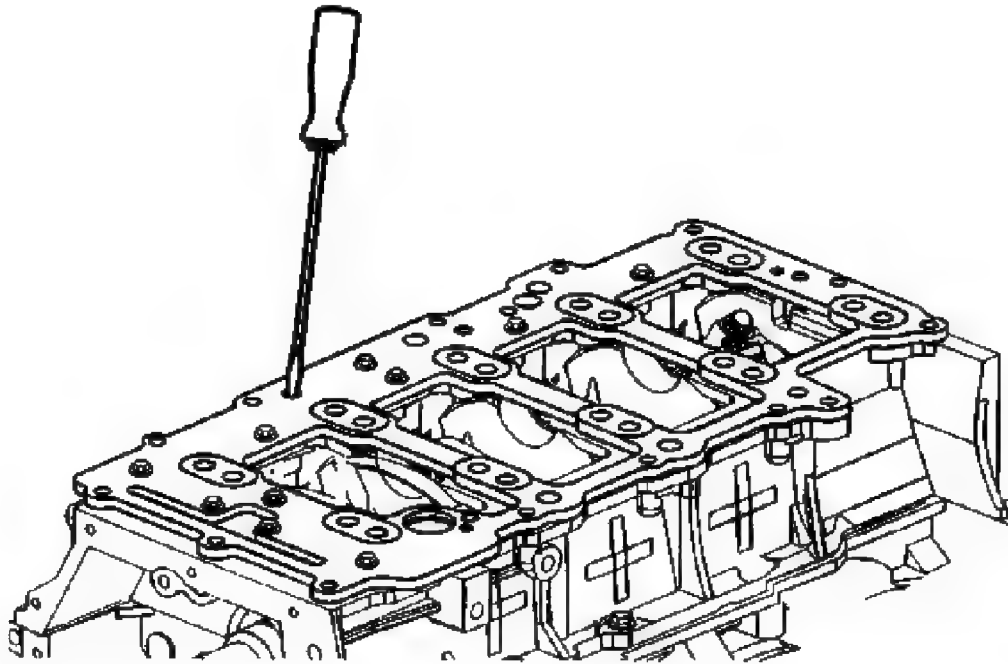


Fig. 318: Cleaning Out Sealant In Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

17. Using a small long blade screwdriver clean out any sealant in the oil drain back passages.

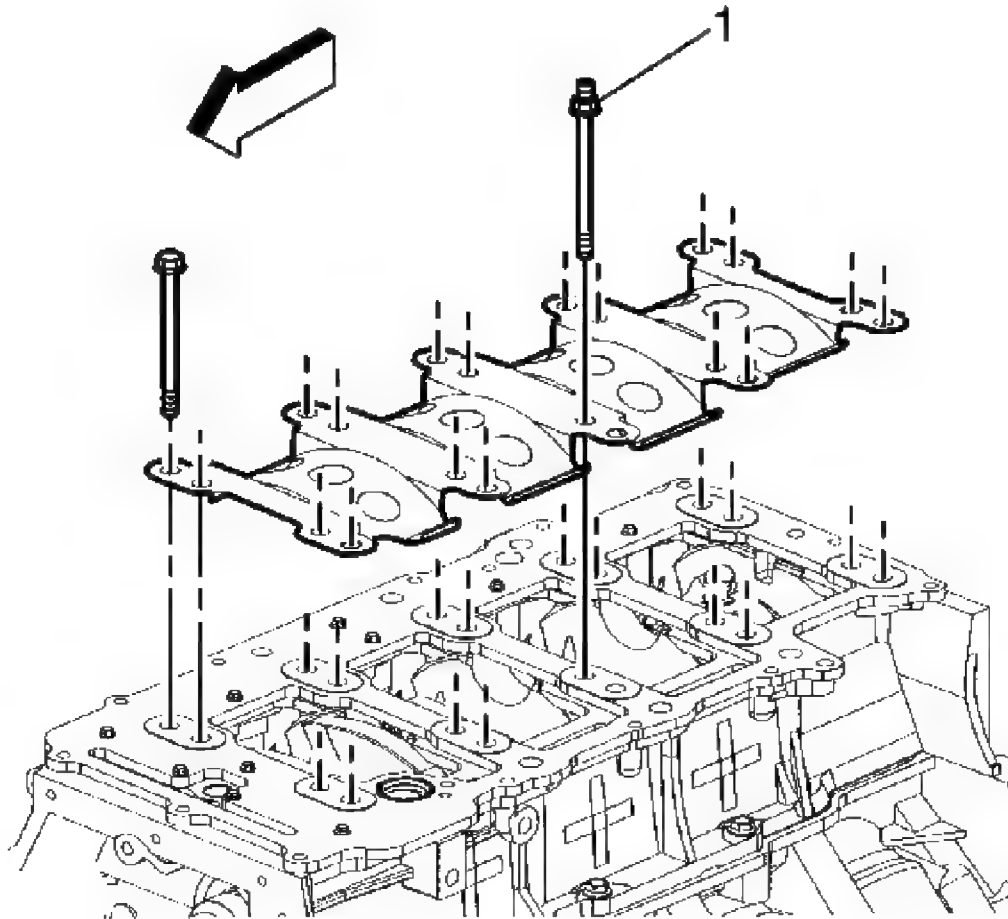


Fig. 319: Locating Oil Pump Pickup Tube Single Stud-End Bolt
Courtesy of GENERAL MOTORS CORP.

18. Install the crankshaft oil scraper plate.
19. Install the main bearing bolts. Ensure the stud-head bolt (1) used for the oil suction tube support bracket is placed in the proper position.

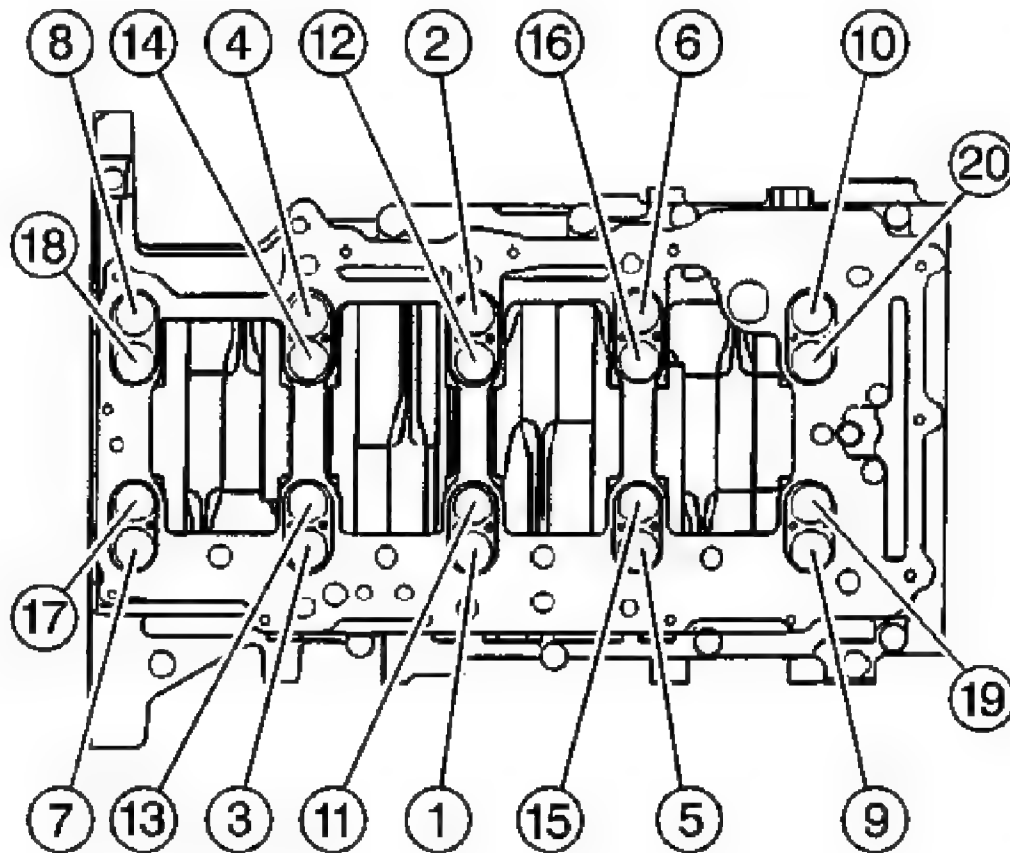


Fig. 320: Identifying Lower Crankcase Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

20. Tighten the main bearing bolts in the proper sequence.

1. First Pass

Tighten: Tighten the main bearing bolts (1-20) to 20 N.m (15 lb ft) in the proper sequence.

2. Final Pass

Tighten: Tighten the main bearing bolts (1-20) an additional 65 degrees in the proper sequence using the J 45059 .

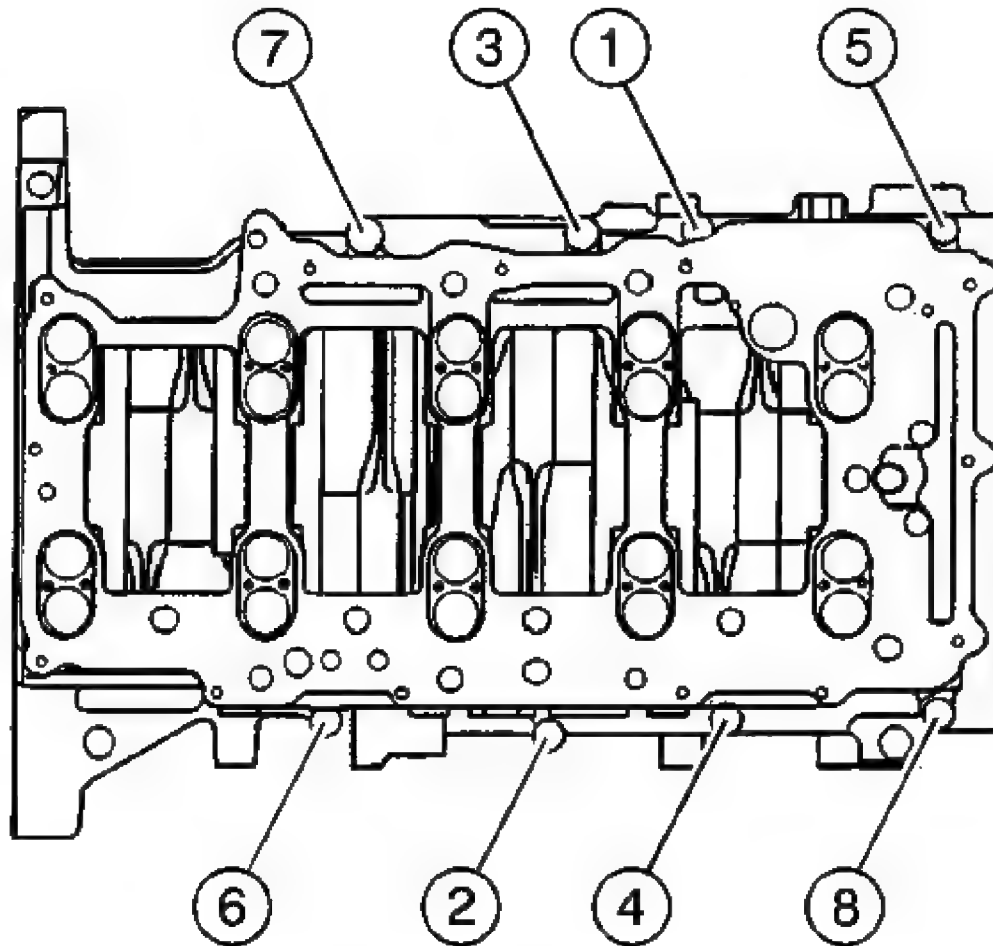


Fig. 321: Identifying Upper-To-Lower Crankcase Perimeter Bolts Tightening Sequence

Courtesy of GENERAL MOTORS CORP.

21. Tighten the crankcase perimeter bolts in sequence shown.

Tighten: Tighten the crankcase perimeter bolts to 30 N.m (22 lb ft).

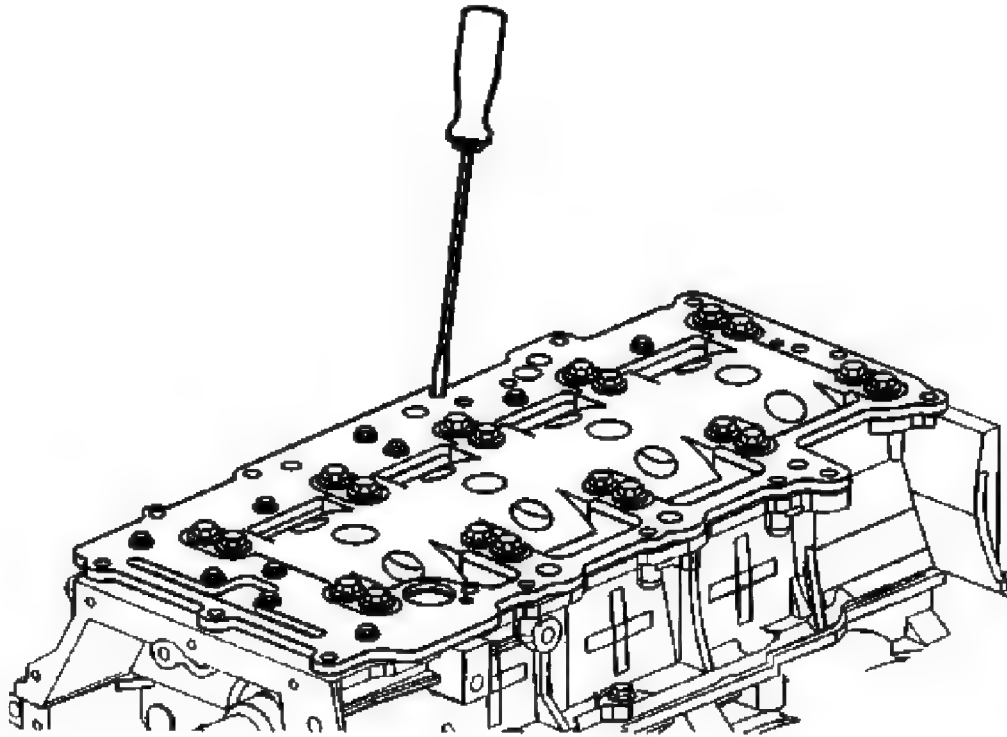


Fig. 322: Cleaning Out Sealant In Oil Drain Back Passages
Courtesy of GENERAL MOTORS CORP.

22. Using a small long blade screwdriver verify that the threaded holes for the oil pan bolts and the oil drain back passages are clear of sealant.
23. Using the **J 39946** rotate the crankshaft until the number one piston is at top dead center (TDC) and the crankshaft key way is approximately at the 7 o'clock position. See **Special Tools** .

OIL PUMP SUCTION PIPE AND SCREEN ASSEMBLY INSTALLATION

INSTALLATION PROCEDURE

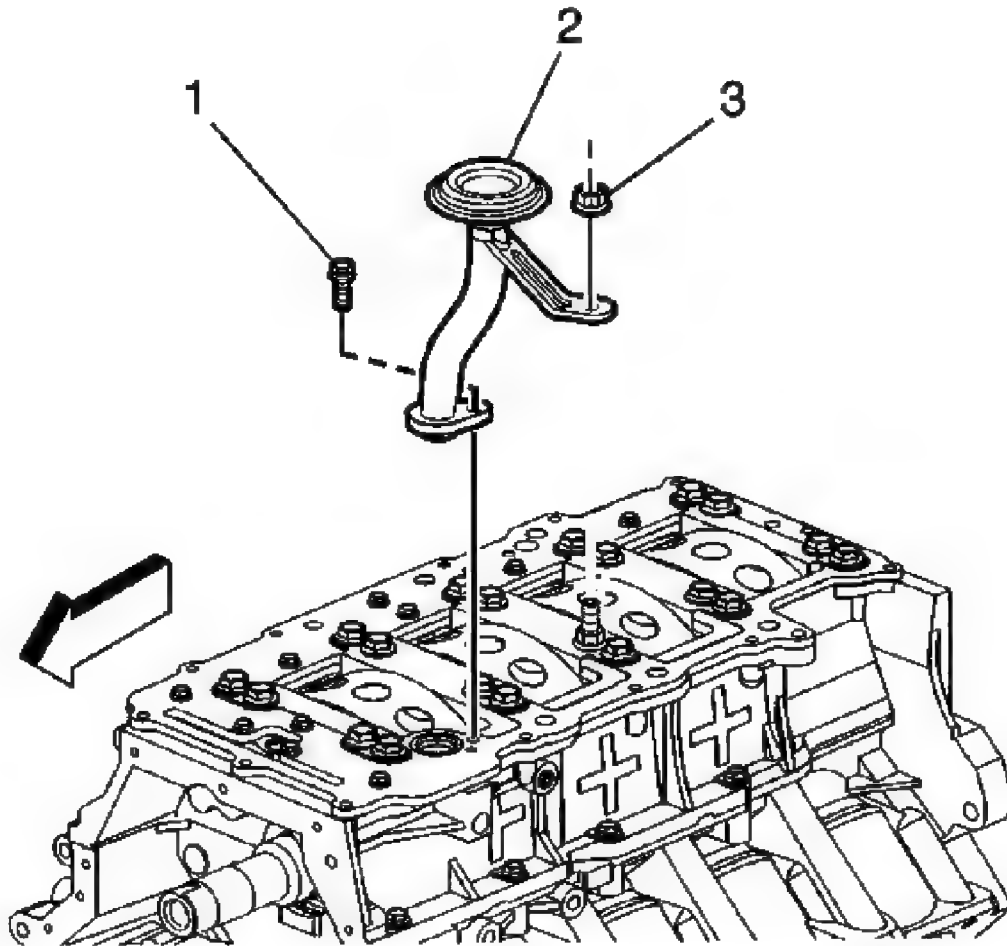


Fig. 323: Identifying Oil Pump Pickup Tube Support Nut, Oil Manifold Mounting Bolt & Oil Pump Pickup Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the silicone seal in the oil manifold plate. With a twisting motion, install the end of the oil pump pick-up tube (2).

NOTE: Refer to SPECIAL FASTENER NOTICE .

2. Install the oil pump pick-up retaining bolt (1) and nut (3).

Tighten:

- Tighten the oil pump pick-up tube nut to 24 N.m (18 lb ft).
- Tighten the oil pump pick-up tube bolt to 10 N.m (89 lb in).

OIL PAN INSTALLATION

TOOLS REQUIRED

EN 46109 Guide Pins. See Special Tools .

INSTALLATION PROCEDURE

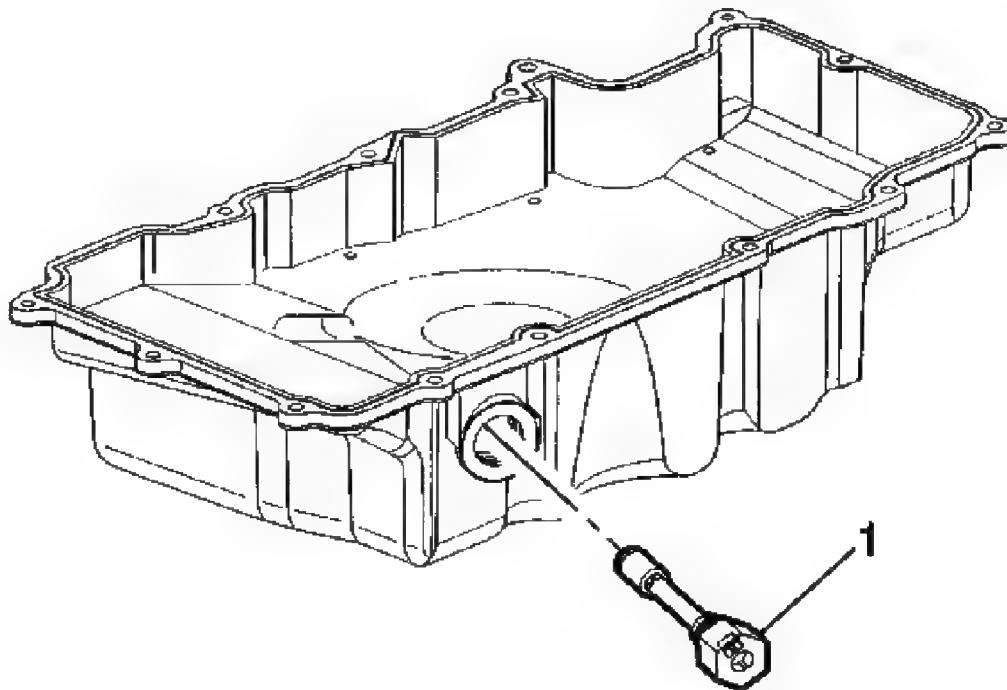


Fig. 324: Identifying Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to SPECIAL FASTENER NOTICE in Cautions and Notices.

1. Install the oil level switch (1).

Tighten: Tighten the oil level switch to 20 N.m (15 lb ft).

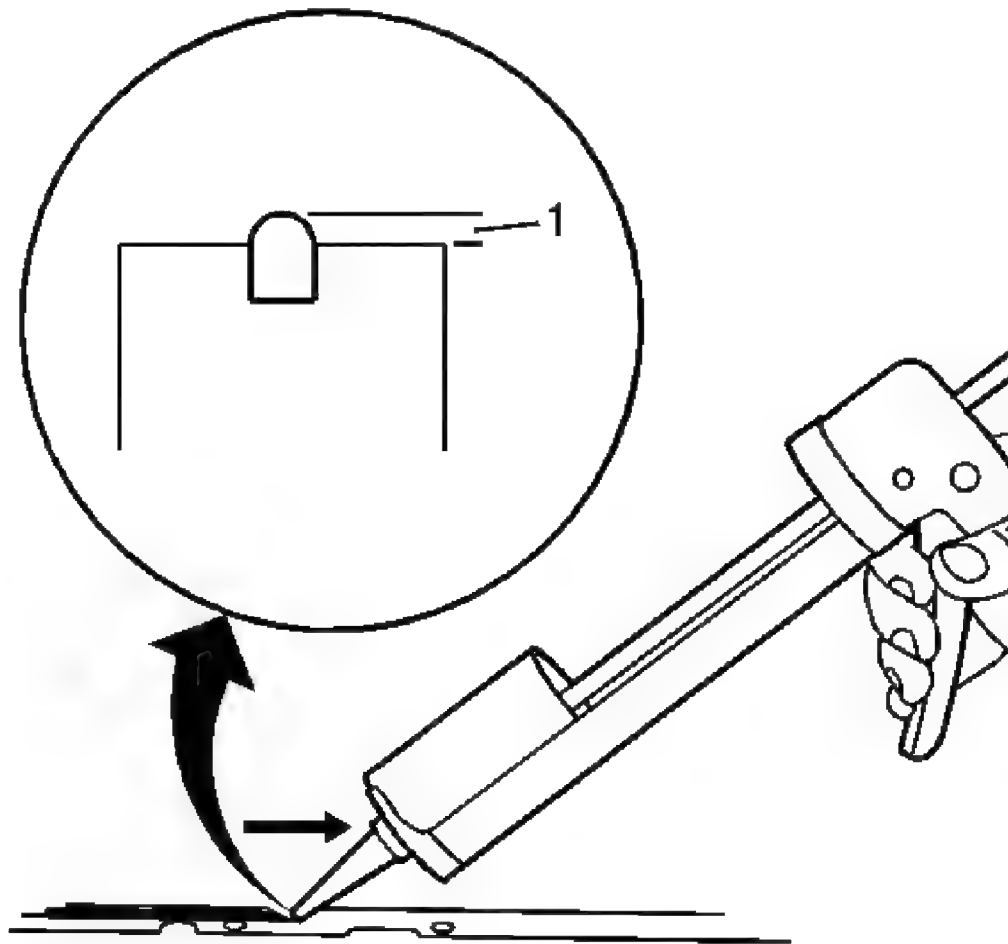


Fig. 325: Applying RTV Sealant
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure components being sealed with room temperature vulcanizing (RTV) sealant are assembled within 20 minutes. Components assembled after the RTV sealant has skinned-over, approximately 20 minutes, will not seal properly.

2. Completely fill and slightly overfill the oil pan seal groove with a continuous bead of RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent.
3. Ensure the RTV sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent bead is higher than the oil pan sealing surface (1) by 3 mm (0.118 in).

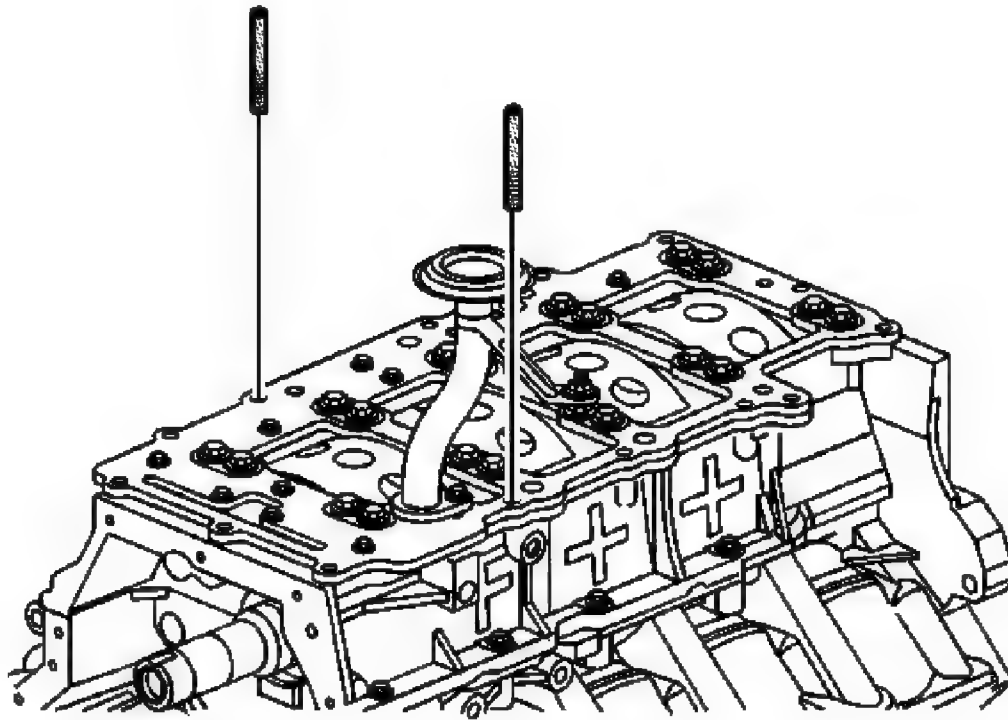


Fig. 326: Identifying EN 46109 Guide Pins
Courtesy of GENERAL MOTORS CORP.

4. To prevent shifting of the oil pan, install one **EN 46109** into a bolt hole in each side of the lower crankcase. See **Special Tools** .

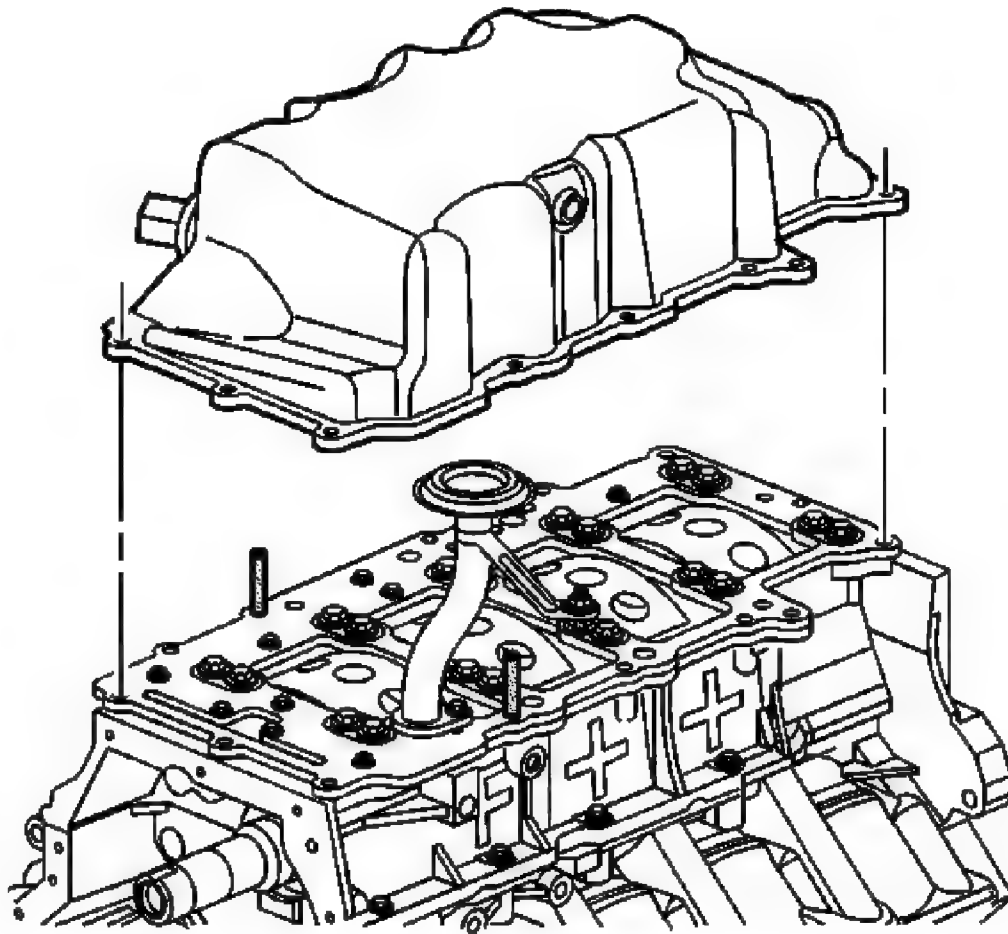


Fig. 327: View Of Oil Pan

Courtesy of GENERAL MOTORS CORP.

5. Position the oil pan onto the lower crankcase.

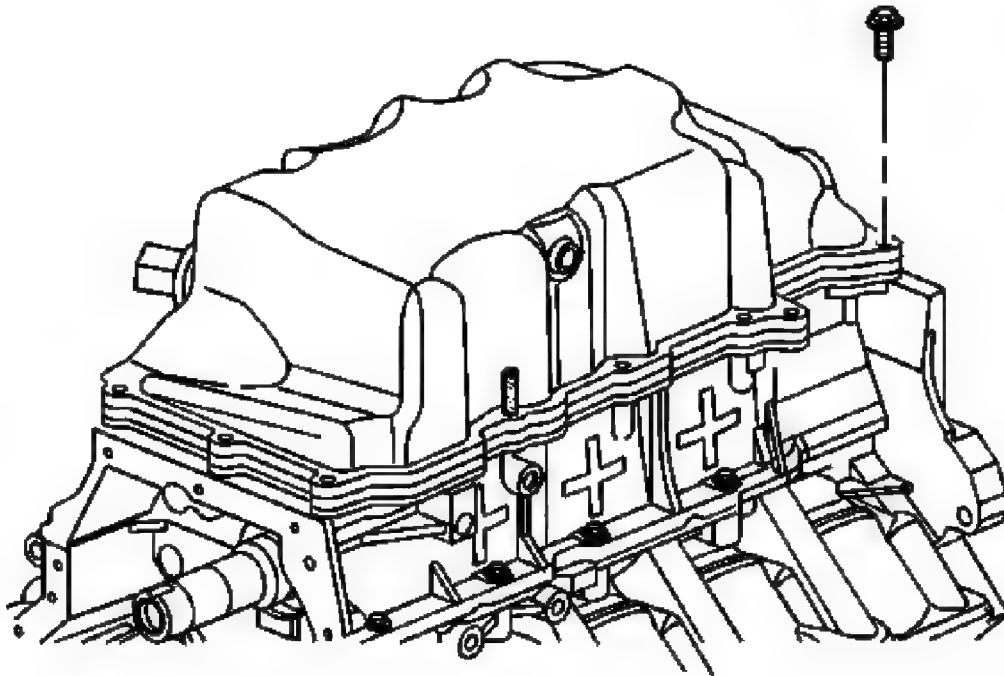


Fig. 328: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

6. Loosely install several of the oil pan bolts.
7. Remove the **EN 46109** . See **Special Tools** .
8. Finish loosely installing the remaining oil pan bolts.

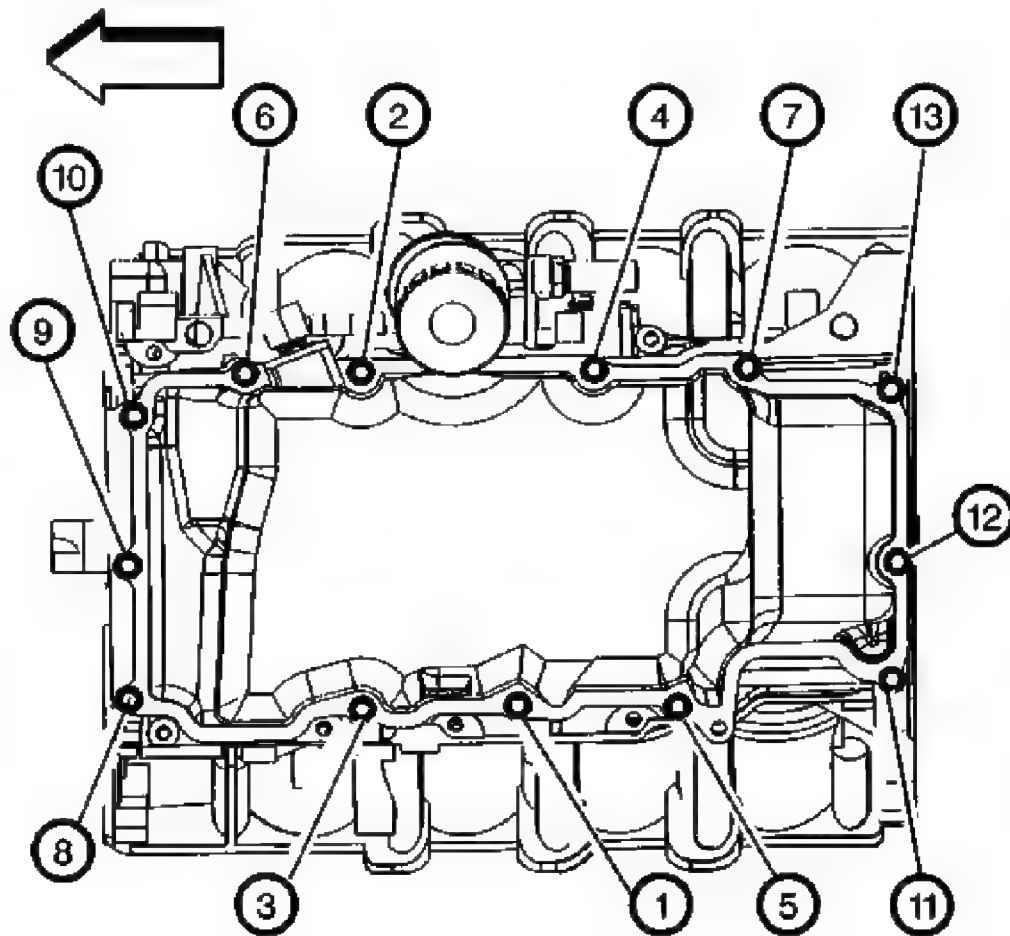


Fig. 329: Identifying Oil Pan Bolts Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

9. Tighten the oil pan bolts in the sequence shown.

Tighten:

1. Tighten the oil pan bolts a first pass to 8 N.m (71 lb in) in the sequence shown.
2. Tighten the oil pan bolts a final pass to 12 N.m (106 lb in) in the sequence shown.

10. Clean off any sealant that has protruded to the exterior of the engine.

CYLINDER HEAD INSTALLATION - LEFT SIDE

TOOLS REQUIRED

J 45059 Angle Meter

INSTALLATION PROCEDURE

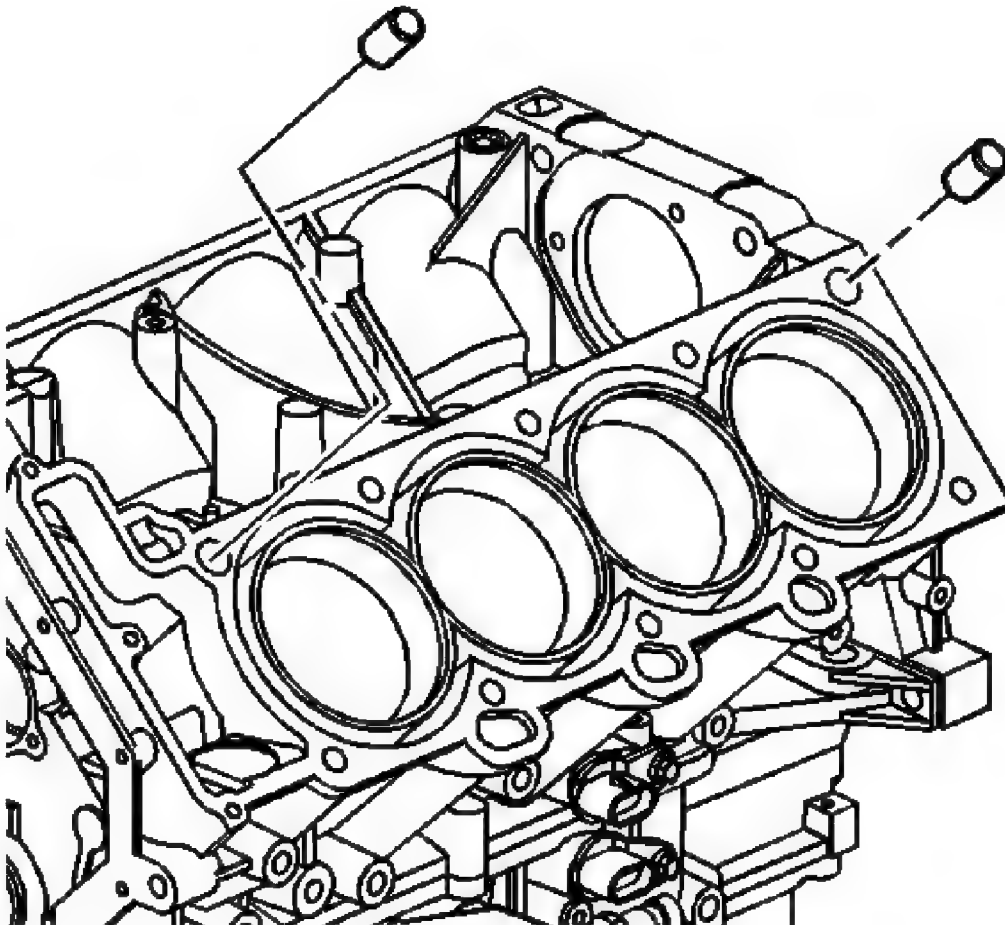


Fig. 330: Identifying Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

1. Ensure all the cylinder head locating pins are securely mounted in the cylinder block deck face.

IMPORTANT: Failure to remove all the old thread sealant material from the cylinder block could cause false torque readings.

2. Ensure any old thread sealant material is removed from the cylinder head bolt holes in the cylinder block.

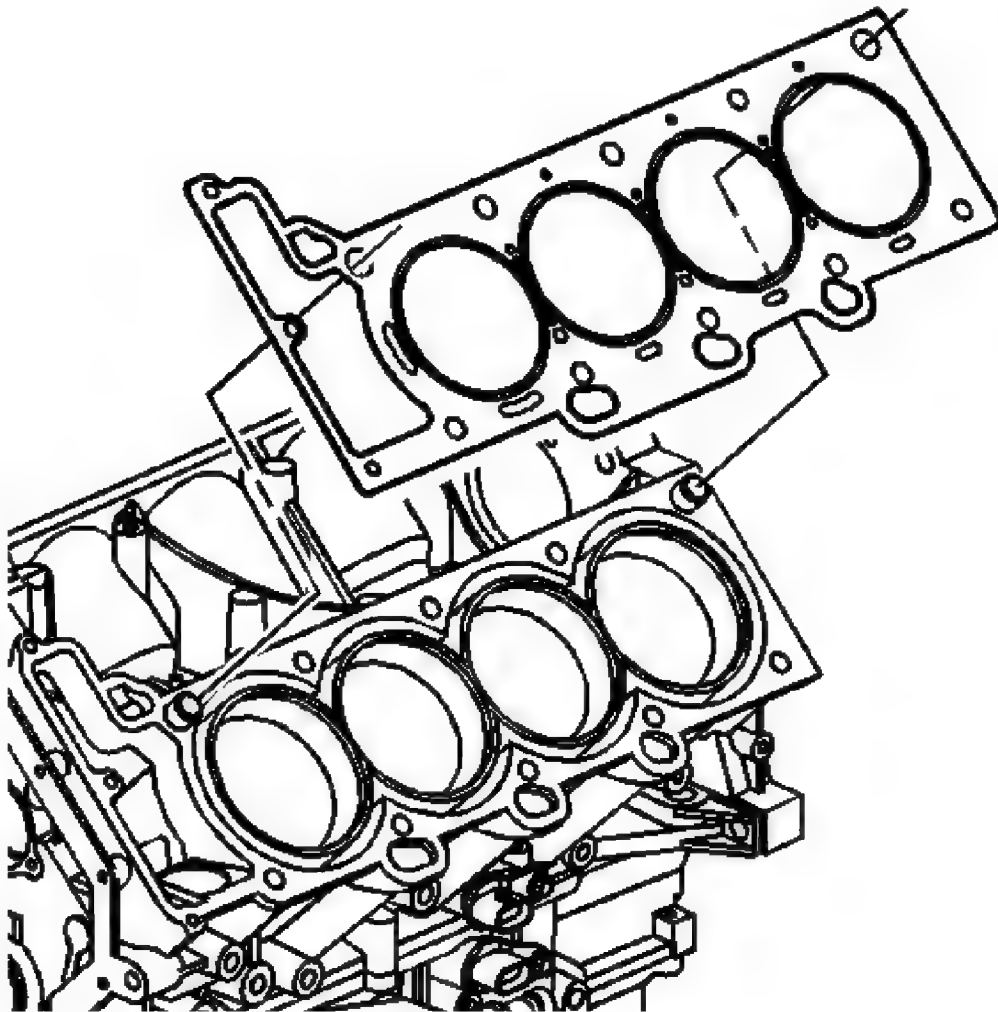


Fig. 331: View Of Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install a new left cylinder head gasket using the deck face locating pins for retention.

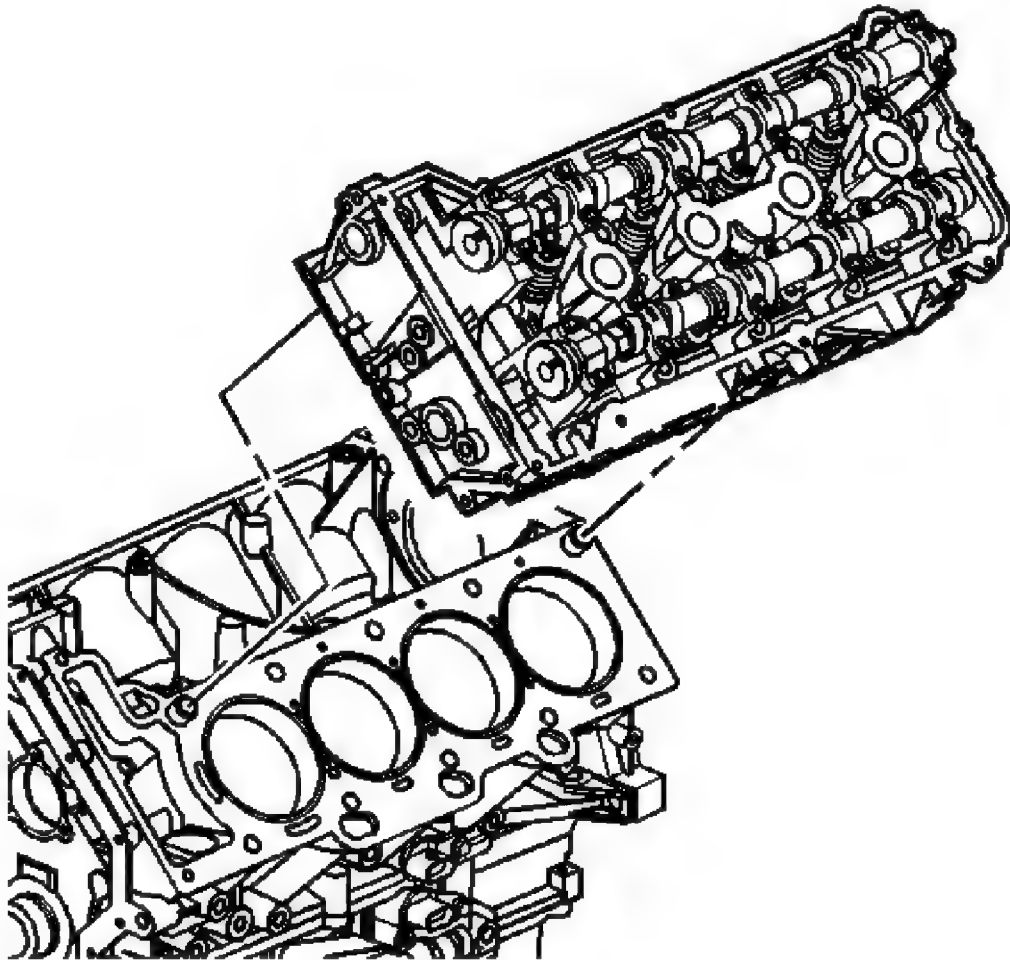


Fig. 332: View Of Cylinder Head With Alignment Dowels - Left
Courtesy of GENERAL MOTORS CORP.

4. Align the cylinder head with the deck face locating pins.
5. Place the cylinder head in position on the deck face.

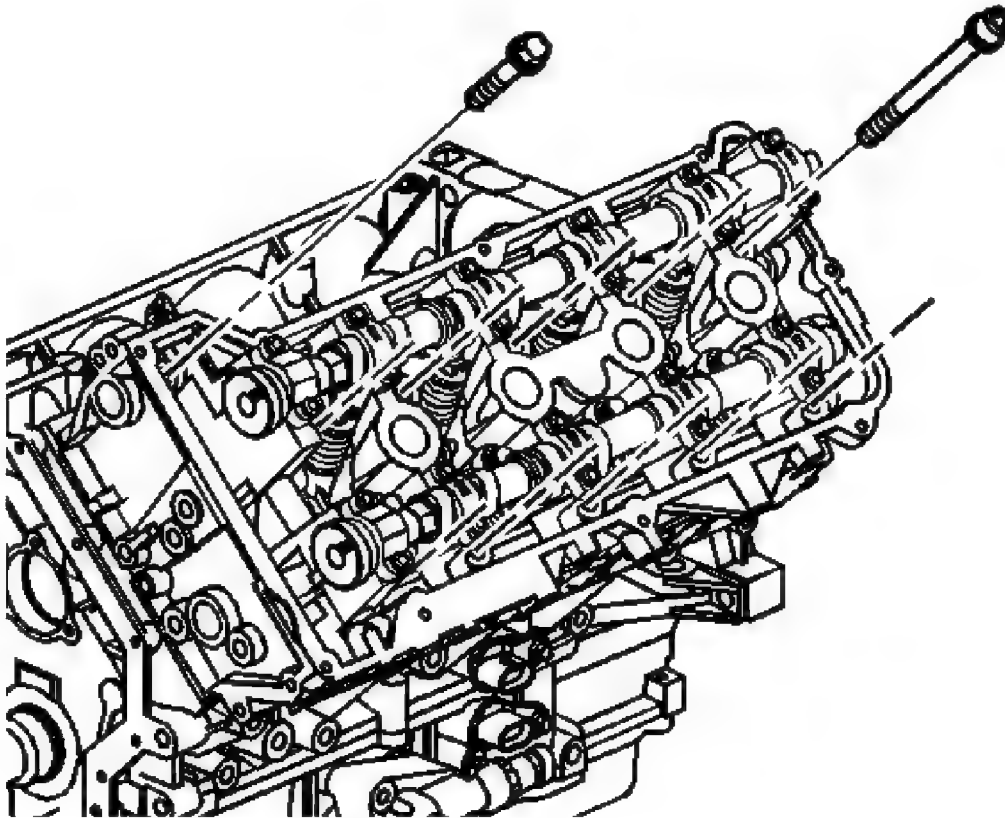


Fig. 333: Locating Cylinder Head External Drive Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the old M11 cylinder head bolts.

6. Install new M11 cylinder head bolts in the cylinder head.
7. Install the M6 cylinder head bolts at the front of the cylinder head.

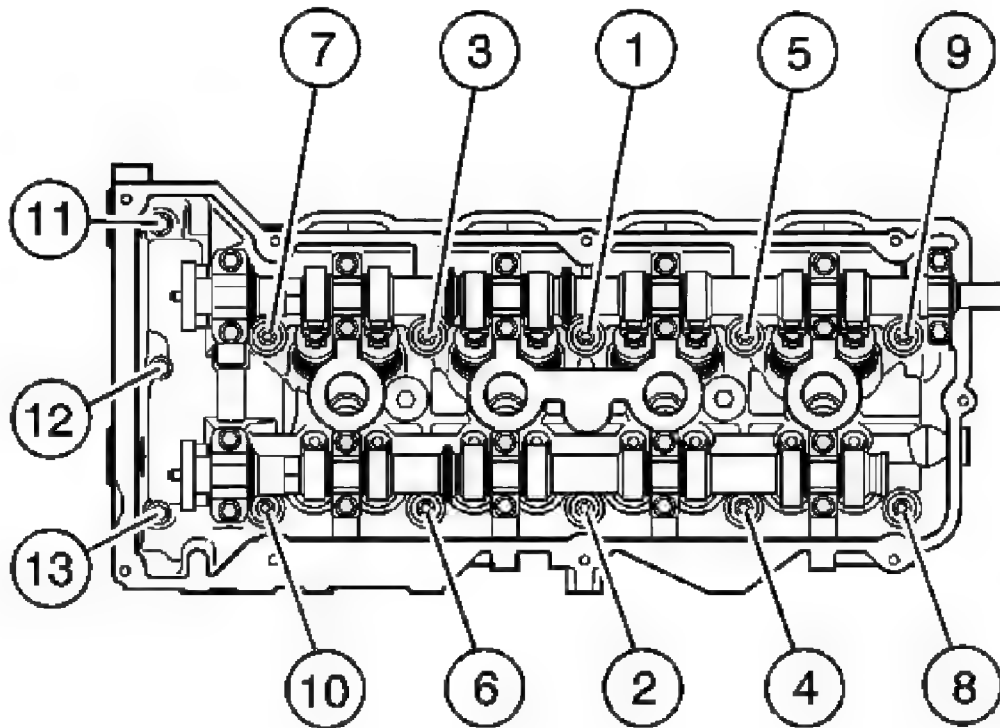


Fig. 334: Identifying Left Cylinder Head Bolts Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

NOTE: Ensure the cylinder head bolts that are being used are the proper pitch or engine damage will occur. The thread pitch on the M11 cylinder head bolts and the engine block cylinder head bolt holes have been revised. In order to prevent engine damage it is important to identify which thread pitch is being used. Cylinder head bolts with a pitch of 1.5 mm have a thread length of about 48 mm (1.890 in) long. Cylinder head bolts with a pitch of 2.0 mm have a thread length of about 67 mm (2.638 in) long.

8. Tighten the left cylinder head bolts in the sequence shown.

1. First Pass

Tighten: Tighten the left cylinder head M11 cylinder head bolts to 30 N.m (22 lb

ft) in the sequence shown.

2. Second Pass

Tighten: Using the **J 45059** , tighten the left cylinder head M11 cylinder head bolts an additional 60 degrees in the sequence shown.

3. Third Pass

Tighten: Repeat the sequence turning each bolt another 60 degrees.

4. Final Pass

Tighten: Repeat the sequence again turning each bolt a final 60 degrees, total 180 degrees.

9. Tighten the M6 bolts at the front of the cylinder head.

Tighten: Tighten the M6 cylinder head bolts to 12 N.m (106 lb in).

CYLINDER HEAD INSTALLATION - RIGHT SIDE

TOOLS REQUIRED

J 45059 Angle Meter

INSTALLATION PROCEDURE

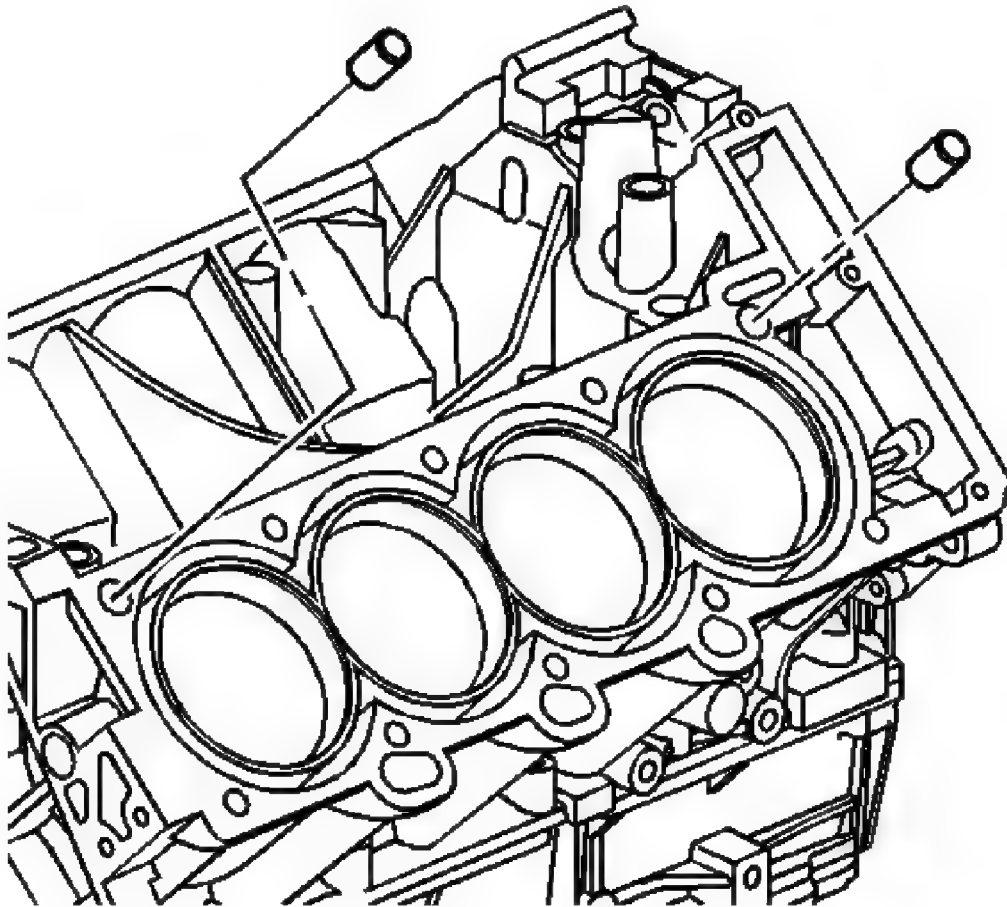


Fig. 335: Identifying Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

1. Ensure all the cylinder head locating pins are securely mounted in the cylinder block deck face.

IMPORTANT: Failure to remove all the old thread sealant material from the cylinder block could cause false torque readings.

2. Ensure any old thread sealant material is removed from the cylinder head bolt holes in the cylinder block.

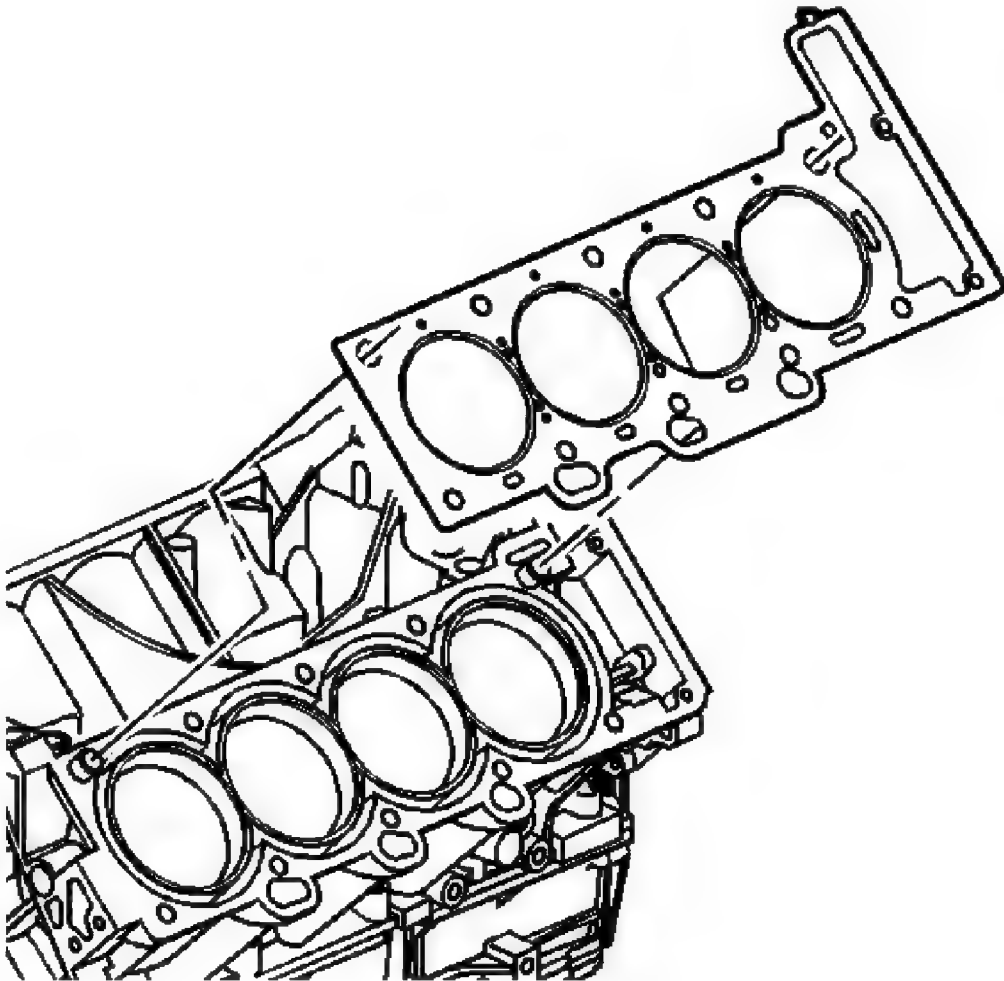


Fig. 336: View of Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install a new right cylinder head gasket using the deck face locating pins for retention.

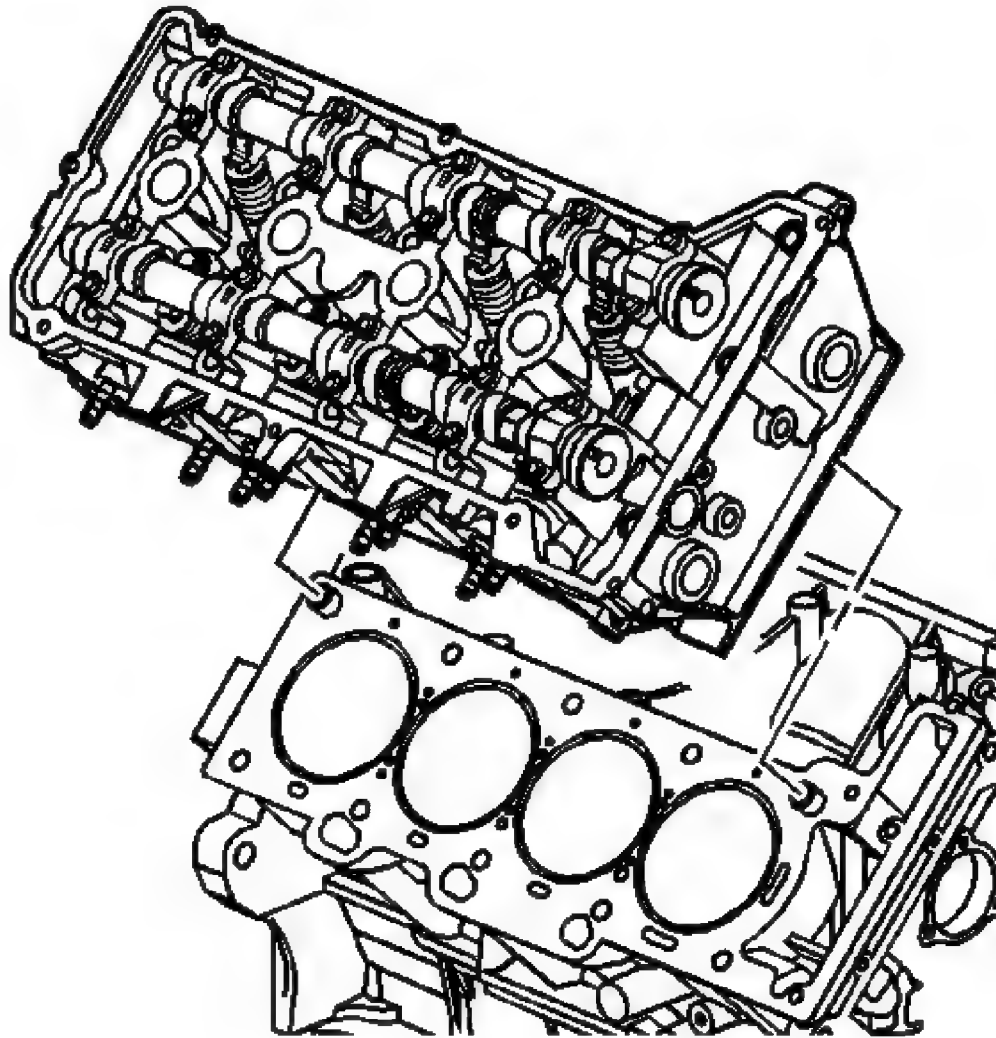


Fig. 337: View Of Cylinder Head With Alignment Dowels - Right
Courtesy of GENERAL MOTORS CORP.

4. Align the cylinder head with the deck face locating pins.
5. Place the cylinder head in position on the deck face.

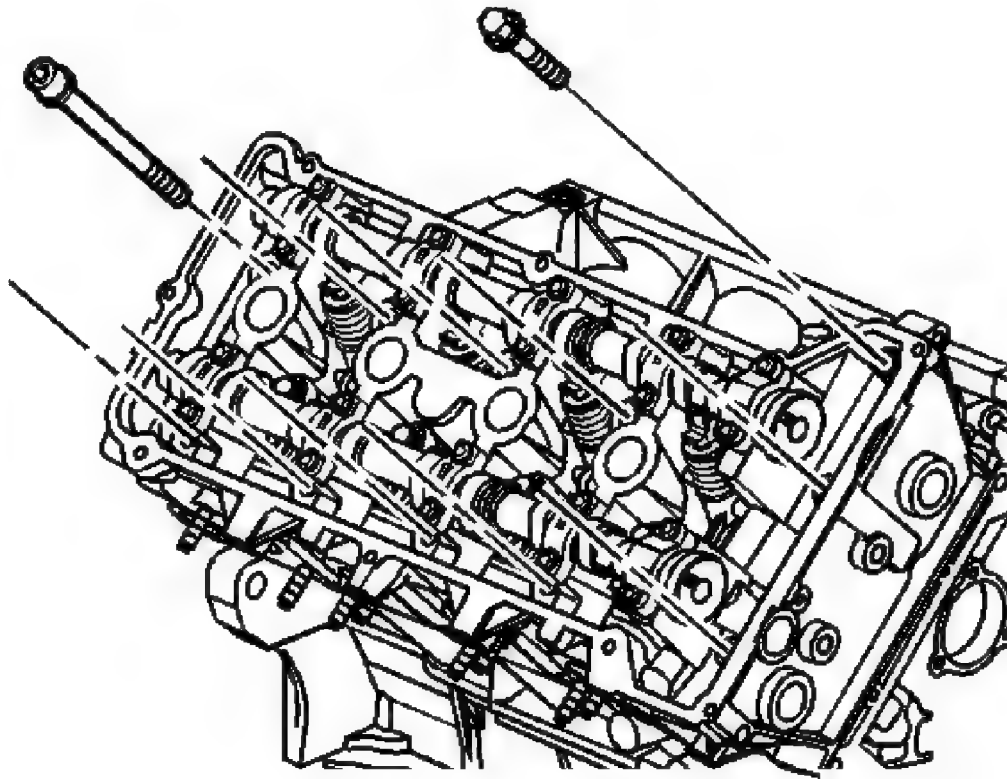


Fig. 338: Locating Right Cylinder Head External Drive Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT reuse the old M11 cylinder head bolts.

6. Install new M11 cylinder head bolts in the cylinder head.
7. Install the M6 cylinder head bolts at the front of the cylinder head.

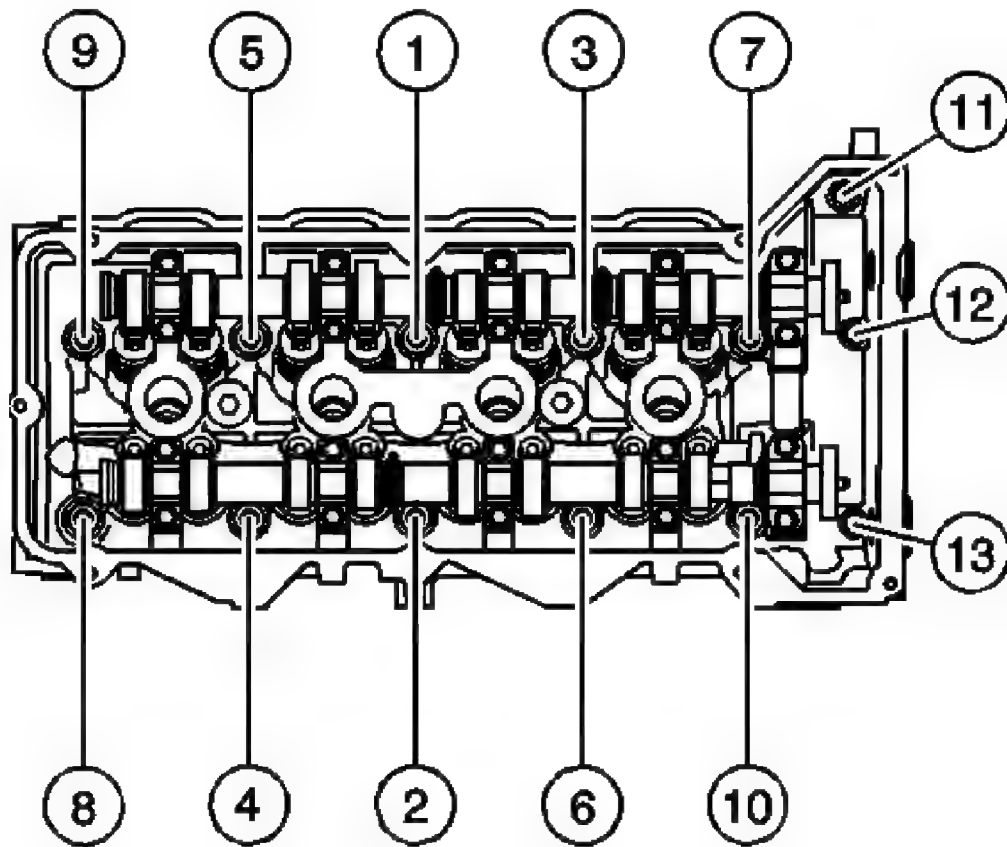


Fig. 339: Identifying Right Cylinder Head Bolts Tightening Sequence
 Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

NOTE: Ensure the cylinder head bolts that are being used are the proper pitch or engine damage will occur. The thread pitch on the M11 cylinder head bolts and the engine block cylinder head bolt holes have been revised. In order to prevent engine damage it is important to identify which thread pitch is being used. Cylinder head bolts with a pitch of 1.5 mm have a thread length of about 48 mm (1.890 in) long. Cylinder head bolts with a pitch of 2.0 mm have a thread length of about 67 mm (2.638 in) long.

8. Tighten the right cylinder head bolts in the sequence shown.

1. First Pass

Tighten: Tighten the right cylinder head M11 cylinder head bolts to 30 N.m (22 lb ft) in the sequence shown.

2. Second Pass

Tighten: Using the **J 45059** , tighten the right cylinder head M11 cylinder head bolts an additional 60 degrees in the sequence shown.

3. Third Pass

Tighten: Repeat the sequence turning each bolt another 60 degrees.

4. Final Pass

Tighten: Repeat the sequence again turning each bolt a final 60 degrees, total 180 degrees.

9. Tighten the M6 bolts at the front of the cylinder head.

Tighten: Tighten the M6 cylinder head bolts to 12 N.m (106 lb in).

VALVE LIFTER INSTALLATION - LEFT SIDE

TOOLS REQUIRED

J 39946 Crankshaft Socket. See **Special Tools** 4.6L

INSTALLATION PROCEDURE

1. Ensure the crankshaft is in the TDC position for the number one cylinder using the **J 39946** . See **Special Tools** .

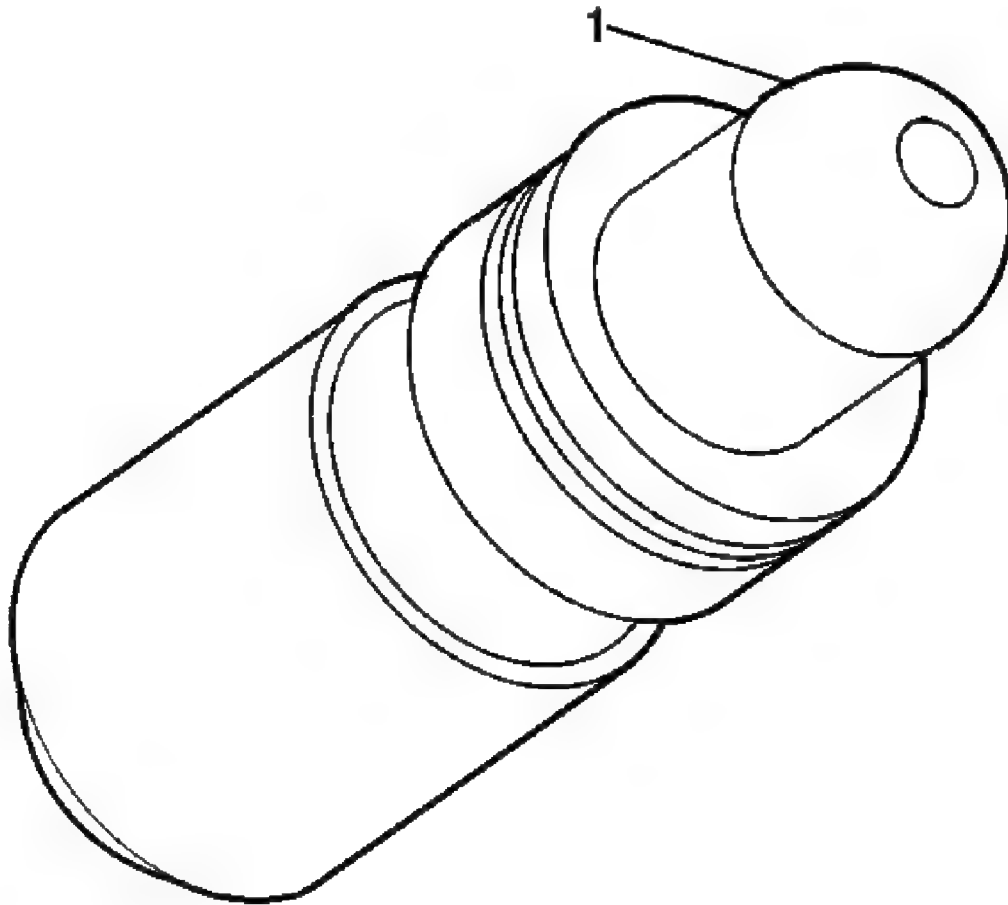


Fig. 340: View Of Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to VALVE LIFTER PRIMING NOTICE .

2. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil GM P/N 12345616 (Canadian P/N 993182) or equivalent. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
3. Lubricate the SHLA bores of the cylinder head with clean engine oil GM P/N 12345616 (Canadian P/N 993182) or equivalent.

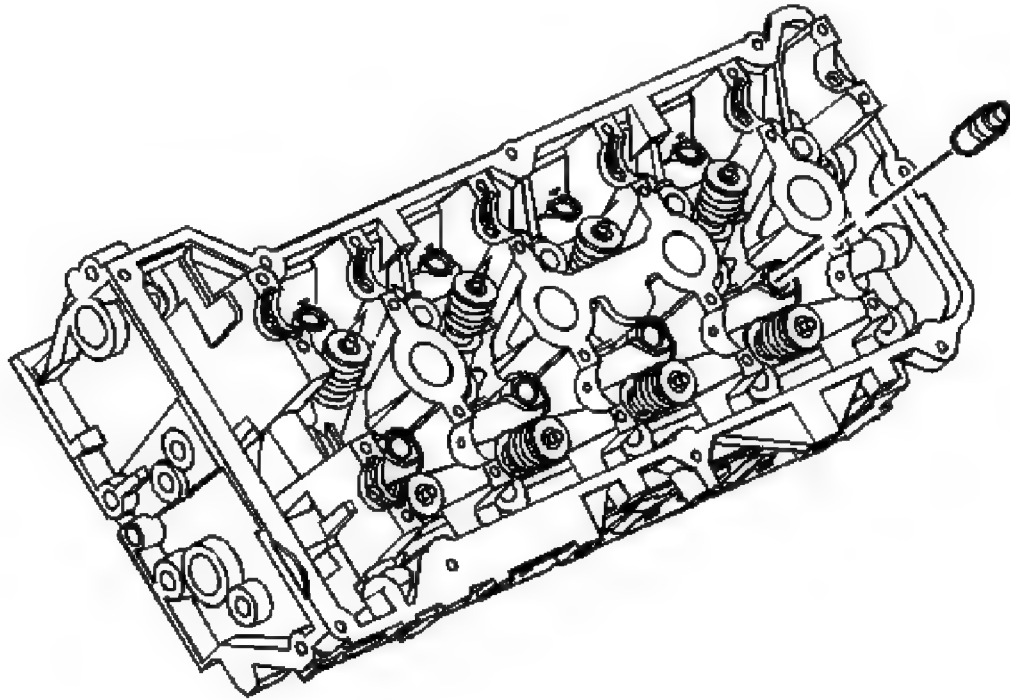


Fig. 341: Locating Left Stationary Hydraulic Lash Adjusters (SHLA)
Courtesy of GENERAL MOTORS CORP.

4. Install the SHLAs.
5. Apply a liberal amount of lubricant GM P/N 12345001 (Canadian P/N 992704) or equivalent to the SHLA sphere.

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